REMEDIAL INVESTIGATION REPORT OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

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ACRONYM LIST

 $\mu g/m^3$ Micrograms Per Cubic Meter $\mu g/kg$ Micrograms Per Kilogram $\mu g/L$ Micrograms Per Liter

2,4-Dichlorophenoxyacetic Acid
AAC

2,4-Dichlorophenoxyacetic Acid
Alaska Administrative Code

ADEC Alaska Department of Environmental Conservation

ADFG Alaska Department of Fish and Game
ADOT Alaska Department of Transportation
AEHA Army Environmental Hygiene Agency

AFB Air Force Base

ARARS Applicable or Relevant and Appropriate Requirements
ARDL Applied Research and Development Laboratory

Army United States Army

As Arsenic

ASTM American Society for Testing and Materials

atm Atmosphere

ATSDR Agency for Toxic Substances and Disease Registry

BaSO₄ Barium Sulfate

BGS Below Ground Surface

BNAs Base/Neutral and Acid Extractable Organic Compounds

BOD Biochemical Oxygen Demand

BTEX Benzene, Toluene, Ethylbenzene, and Total Xylenes

BTU British Thermal Units

Ca(Mg)HCO₃ Calcium Magnesium Carbonate CAS Columbia Analytical Services

CERCLA Comprehensive Environmental Response, Compensation, and

Liability Act

CF Calibration Factor

CFR Code of Federal Regulations
COPCs Contaminants of Potential Concern

Corps United States Army Corps of Engineers, Alaska District

CQAR Chemical Quality Assurance Report

Cr Chromium

CRREL Cold Regions Research and Engineering Laboratory

CSM Conceptual Site Model

CSY Coal Storage Yard

Cu Copper

DCA Dichloroethane
DCE Dichloroethene

DDD Dichlorodiphenyldichloroethane
DDE Dichlorodiphenyldichloroethylene
DDT Dichlorodiphenyltrichloroethane

dh/dl Hydraulic Gradient

DNAPLs Dense Nonaqueous Phase Liquids

DO Dissolved Oxygen

DoD United States Department of Defense
DOI United States Department of the Interior

DPW Directorate of Public Works
DQOs Data Quality Objectives
DRO Diesel-Range Organics

E & E Ecology and Environment, Inc.
ECD Electron Capture Detector
Eh Reduction Oxidation Potential

EM Electromagnetic EP Extraction Procedure

EPA United States Environmental Protection Agency

ERA Ecological Risk Assessment
ESA Endangered Species Act

ESE Environmental Services and Engineering

EVT Evapotranspiration
FEP Fairbanks-Eielson Pipeline
FFA Federal Facilities Agreement
FID Flame Ionization Detector

FS Feasibility Study

FSPH Field Screening Petroleum Hydrocarbons
FSVOC Field Screening Volatile Organic Compounds

ft/ft Foot Per Foot
ft/mile Feet Per Mile
ft/second Feet Per Second
ft/year Feet Per Year
ft/day Feet Per Day
FTPs Fire Training Pits

fuel ID Petroleum Hydrocarbon Product Identification

g/mole Grams Per Mole

gal/feet/day Gallons Per Feet Per Day
GC Gas Chromatograph
gpd Gallons Per Day

gpd/ft Gallons Per Day Per Feet

GPR Ground-Penetrating Radar GRO Gasoline-Range Organics

GW Groundwater

GWAP Graphical Well Analysis Program

Hg Mercury

HHRA Human Health Risk Assessment

HIs Hazard Indices

HLA Harding Lawson and Associates, Inc.

HpCDD Heptachlorodibenzo-p-dioxin **HpCDF** Heptachlorodibenzofuran **HpCDF** Heptachlorodibenzofuran **HxCDD** Hexachlorodibenzo-p-dioxin **HxCDD** Hexachlorodibenzo-p-dioxin Hexachlorodibenzo-p-dioxin **HxCDD** Hexachlorodibenzofuran HxCDF **HxCDF** Hexachlorodibenzofuran

ID Inside Diameter
JFS Joint Federal Studies

K Potassium

kg/day Kilograms Per Day kg/year Kilograms Per Year

LNAPLs Light Nonaqueous Phase Liquids
LOEL Lowest Observed Effect Level
m&p-Xylene meta-Xylene and para-Xylene
m³/mol Cubic Meters Per Mole

MCLs Maximum Contaminant Levels

MEK Methyl Ethyl Ketone
mg/L Milligrams Per Liter
mg/kg Milligrams Per Kilogram

mHz Megahertz
mL Milliliters
mm Millimeters

mmho/m Millimhos Per Meter
MP Management Plan
mph Miles Per Hour
MS Matrix Spike

MSD Matrix Spike Duplicate

MSL Mean Sea Level

MUS Municipal Utilities Service

N Nitrogen

NAPL Nonaqueous Phase Liquid

NET National Environmental Testing, Inc.
NHPA National Historic Preservation Act

NIPDWR National Interim Primary Drinking Water Regulations

NMFS National Marine Fisheries Services

NOAA National Oceanic and Atmospheric Administration

NPDML North Pacific Division Materials Laboratory

NPL National Priorities List

NSDWR National Secondary Drinking Water Regulations

NSF National Sanitation Foundation NTUs Nephelometric Turbidity Units

o-Xylene ortho-Xylene

OCDD Octachlorodibenzo-p-dioxin
OCDF Octachlorodibenzofuran
OD Outside Diameter

OL Organic Silt
OU-4 Operable Unit 4

PACAF United States Department of Air Force, Detachment 1,

354th Weather Squadron

PAHs Polynuclear Aromatic Hydrocarbons

PARCC Precision, Accuracy, Representativeness, Completeness,

and Comparability

PCA Tetrachloroethane

PCBs Polychlorinated Biphenyls

PCE Tetrachloroethylene

PeCDD Pentachlorodibenzo-p-dioxin
PeCDF Pentachlorodibenzofuran
PET Potential Evapotranspiration

pg/g Parts Per Trillion

PID Photoionization Detector

POLs Petroleum, Oil, and Lubricants

ppg Parts Per Gram
ppm Parts Per Million
psi Pounds Per Square Inch
PVC Polyvinyl Chloride
QA Quality Assurance
OC Quality Control

RBC Risk-Based Concentration

RCRA Resource Conservation and Recovery Act

RI Remedial Investigation

RIR Remedial Investigation Report
ROLF Railcar Off-Loading Facility
RPD Relative Percent Difference
RSD Relative Standard Deviation

Sb Antimony

semi-VOCs Semivolatile Organic Compounds

SM Silty Sand

SOP Standard Operating Procedure

SP Poorly Sorted Sand Transmissivity

TBCs To-Be-Considered Criteria

TCA Trichloroethane

TCDD Tetrachlorodibenzo-p-dioxin TCDF Tetrachlorodibenzofuran

TCE Trichloroethene

TCLP Toxicity Characteristic Leaching Procedure

TDS Total Dissolved Solids

TDEM Time Domain Electromagnetic
TEF Toxicity Equivalency Factor
TOC Total Organic Carbon
TOX Total Organic Halides

TPH Total Petroleum Hydrocarbons

TRPH Total Recoverable Petroleum Hydrocarbons

UCL Upper Confidence Limit

USACE United States Army Corps of Engineers
USFWS United States Fish and Wildlife Service

USGS United States Geological Survey
UST Underground Storage Tank
VOA Volatile Organic Analysis
VOCs Volatile Organic Compounds
WCC Woodward-Clyde Consultants

EXECUTIVE SUMMARY

This document represents the completion of a remedial investigation (RI) conducted by Ecology and Environment, Inc., (E & E) at Fort Wainwright, Alaska. A Federal Facilities Agreement (FFA) established by the United States Environmental Protection Agency, the Alaska Department of Environmental Conservation, and the United States Department of Defense in 1992 defined the requirements for completing the RI and feasibility study at Operable Unit 4 (OU-4), which was included on the National Priorities List in 1990. OU-4 was defined in the FFA as including the Landfill Source Area, an active landfill north of Fort Wainwright and the Chena River; the Coal Storage Yard (CSY) Source Area, an area south of Fort Wainwright's Power Plant Coal Storage Yard, currently used for coal storage; and the Fire Training Pits (FTPs) Source Area, an area near the southeast corner of the fort's runway, comprising at least two known cleared areas previously used for fire training exercises.

This document is the draft RI Report that is a companion to two preliminary documents previously submitted in conjunction with the RI. The following documents are pertinent to the OU-4 RI and are considered companions to this draft report, including the previously submitted documents:

- OU-4, Data Presentation (February 1994);
- Approach Document for the Baseline Human Health Risk Assessment, OU-4 (July 1994); and
- Baseline Human Health and Ecological Risk Assessment Report, OU-4 (November 1994).

RI activities were conducted in accordance with an approved Management Plan (E & E 1993) during September and October 1993. Following completion of those activities,

data were compiled and summarized in the Data Presentation Report for review by the agencies. Subsequent fieldwork was defined for the Landfill, CSY; and FTPs and was completed in May and July 1994. Data obtained from the 1993 fieldwork were used for the Approach Document for the Baseline Human Health Risk Assessment. Submitted with this RI report is the Risk Assessment Report that includes the Baseline Human Health and Ecological Risk Assessments.

Inorganic and organic data were reviewed and compared to background or risk-related values in order to establish chemicals of potential concern (COPCs). Inorganic results were compared to source area-specific background values or the United States Army Corps of Engineers (Corps) recommended background values for selected elements, which are described in the Corps' final document, *Background Data Analysis for Arsenic, Barium, Cadmium, Chromium, and Lead*, submitted in March 1994. Analytical results initially were screened in the Approach Document (E & E 1994) to determine a list of COPCs. These COPCs are discussed in this RI and are compared to the more conservative (1×10^{-7} excess cancer risk for carcinogens in soils and sediments, 1×10^{-6} excess cancer risk for carcinogens in water, and hazard quotient of 0.1 for noncarcinogens in all media) human health risk-based concentrations (RBCs) for presentation purposes without regard to risk-based decision making. Human health and ecological risk discussions are reserved for the companion Risk Assessment Report.

Landfill Source Area

The Landfill Source Area includes an active Landfill that accepts waste generated from Fort Wainwright. Refuse is applied in lifts as it is covered with fill material and coal ash provided by Fort Wainwright's coal power plant. The Landfill has not expanded laterally, but has gained approximately 50 feet in height above the natural grade from the many lifts accumulated over the years. Two monitoring wells completed near the west edge of the Landfill during previous investigations (E & E 1990) consistently have indicated groundwater contamination by chlorinated hydrocarbons.

Results of the RI indicate that chlorinated hydrocarbons detected in these wells remain at relatively consistent concentrations. Lower levels of chlorinated hydrocarbons were detected at a downgradient well at the head of the southwest drainage, but not at a downgradient well farther down the drainage. No other groundwater concerns were identified.

North of the Chena River, permafrost is a major influence on groundwater flow at Fort Wainwright and has been characterized as varying in depth and in thickness in areas surrounding the Landfill Source Area. Significant areas where permafrost is apparently absent also correspond to the southwest drainage that is suspected of being a potential migration pathway. The Landfill itself does not appear to be underlain by permafrost, or permafrost is present at depths beyond the resolution of geophysical instruments and the interferences generated by the Landfill refuse. It is suspected that contaminants within the area of the contaminated wells are diluted significantly since they were not detected at downgradient locations. An alternate explanation is that permafrost has limited groundwater flow, that contaminants are not migrating to the downgradient wells.

Contamination in surface soils collected from the Landfill cover (i.e., ash) and surrounding drainages did not exceed any United States Environmental Protection Agency (EPA) regulatory benchmarks. Barium in the ash cover and arsenic were among the inorganic elements of greatest significance; however, barium was not elevated in the drainage soils. Coal ash continues to be used as a refuse cover at the Landfill.

Contamination as a result of Landfill activities was not identified in surface and subsurface soils, or surface water surrounding the Landfill Source Area.

CRREL work provided by the Corps has been incorporated into the document. Several existing documents and/or information may not have been available to E & E at the time of report generation.

Coal Storage Yard Source Area

The CSY Source Area includes a coal storage yard used to stockpile coal for the Fort Wainwright power plant. Coal is present in two piles: the active coal pile, used for current coal burning operations, and a coal pile used for surplus storage (i.e., emergencies). Prior to 1993, the active coal pile was sprayed with waste fuel to enhance the heat capacity of the coal. This waste fuel was stored in three underground storage tanks (USTs) adjacent to and east of the active coal pile.

Contamination consisting of volatile organic compounds (i.e., benzene, toluene, ethylbenzene, xylenes, and chlorinated hydrocarbons) was identified in subsurface soils and groundwater directly beneath the active coal pile. Chlorinated hydrocarbon contamination in groundwater also was identified in two of the monitoring wells completed around the UST

area. This contamination could not be characterized as part of the plume associated with the active coal pile contamination, and may be related to the UST.

Unfiltered groundwater is contaminated with dioxin and furan congeners at most of the CSY wells; however, concentrations are highest at upgradient locations. Therefore, the source of dioxin/furans in groundwater may be an upgradient source. Coal ash would be a likely source, but ash samples at the Landfill were not contaminated with dioxin/furans. Consequently, it is unknown what the source of dioxin is. Dioxin/furans were not detected in soil samples.

Contaminant migration has not been extensive or the contaminants may have dispersed to undetectable concentrations away from the active coal pile. This may be due to a number of factors, including limited groundwater flow, because of influences from the cooling pond, pumping at nearby wells for water used by the power plant, elevated temperatures in the groundwater from heated water discharged into the cooling pond, and regional groundwater flow.

Fire Training Pits Source Area

The FTPs Source Area, covers a broad vegetated area, including two cleared areas formerly used for fire training exercises. Contamination consisting of inorganics; petroleum hydrocarbons; and chlorinated hydrocarbons, benzene, and pesticides was identified in soils and groundwater, within the cleared areas, and along dirt roadways, apparently not associated with fire training exercises.

Surface soil contamination was predominantly in isolated areas (i.e., hot-spots), and contamination at depth generally decreases or was not present. Groundwater contamination of chlorinated hydrocarbons also was not determined to be laterally extensive and occurs at relatively low concentrations. Petroleum contamination in groundwater was identified in a background well, in addition to downgradient wells along the east edge of the FTPs. This suggests an upgradient and unrelated contaminant source from the fire training pit activities.

1. INTRODUCTION

This document presents the results of a Remedial Investigation (RI) conducted at Operable Unit 4 (OU-4) of the United States Army (Army) Fort Wainwright Facility. The RI was conducted on behalf of Army Alaska, Directorate of Public Works, (DPW) and pursuant to the United States Army Corps of Engineers, Alaska District, (Corps) Contract No.

DACA85-93-D-0009, Delivery Order No. 7. The investigation was conducted under the jurisdiction of the Corps Installation Restoration Program and in accordance with an approved Management Plan (Ecology and Environment, Inc. [E & E] 1993). The objective of the RI is to characterize the nature and extent of contamination resulting from historical practices at the OU-4 source areas. Field activities occurred from August to November 1993 and May to August 1994. The 1993 field activities are described in the OU-4 RI/Feasibility Study (FS) Management Plan (E & E 1993). The 1994 field activities are described in Modification Nos. 4 and 5 to Delivery Order No. 7, dated April 19 and June 6, 1994, respectively. All field and reporting activities were performed in accordance with the contract scope of work (see Appendix A).

Fort Wainwright consists of 918,000 acres on the east side of Fairbanks, within the Fairbanks North Star Borough in central Alaska. All of Fort Wainwright, including OU-4, was placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL) in August 1990. Consequently, a Federal Facilities Agreement (FFA) was executed among the United States Environmental Protection Agency (EPA), the Alaska Department of Environmental Conservation (ADEC), and the United States Department of Defense (DoD) in spring 1992. The FFA details the responsibilities and authority of each party for environmental investigation and remediation requirements pursuant to the CERCLA process. The FFA divided Fort Wainwright into five operable units, one of

which is OU-4, and outlined the general requirements for investigation and remediation of each. According to the FFA, OU-4 comprises three source areas: the Landfill, the Coal Storage Yard (CSY), and the Fire Training Pits (FTPs), hereafter referred to as source areas.

This Remedial Investigation Report (RIR) was developed in accordance with the Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA (EPA 1988). It describes the OU-4 setting, investigative methods, results, and an interpretation of the RI fieldwork. Results of the OU-4 human health and ecological risk assessment will be provided under separate cover.

The RIR is organized into sections that present source area background information, site data and information obtained during the RI, and interpretation of the results. Section 1, the introduction, summarizes the setting, history, and previous investigations for each source area, and Section 2 provides an overview of field investigative methods and sample collection summaries. Section 3 summarizes regional setting. Section 4 describes the data analytical work and presents the results of data quality assurance (QA) reviews generated during the RI. Sections 5, 6, and 7 present analytical results and a description of contaminant distribution and extent for each source area. Contaminant fate and transport are presented in Section 8, and Section 9 provides a summary of the results obtained during the RI and conclusions. The following are appended to this RIR:

- Project scope of work (Appendix A);
- Well water level elevations (Appendix B);
- Soil boring logs and monitoring well construction diagrams (Appendix C);
- Photographic documentation of RI field activities (Appendix D);
- Geotechnical test results for selected soil samples (Appendix E);
- Geophysical data (Appendix F);
- Slug test data (Appendix G);
- Hydrochemical mass balance results (Appendix H);
- The chemical quality assurance report (CQAR) (Appendix I); and
- Analytical data tables (Appendix I).

1.1 SITE BACKGROUND

This section describes, for each of the OU-4 source areas, the source location and physical setting, past practices, and previous investigations. The information presented herein formed the basis for the conceptual site models presented for each source area in the Management Plan and for the associated RI/FS objectives and 1993 field activities (E & E 1993). The general boundaries of the OU-4 source areas are depicted in Figure 1-1. E & E summarized the most important data in tables and discussed others within the body of the document. Inclusion of every detected compound in each medium was not justified because the number of tables would have increased without benefiting the document.

In the following sections, inorganic data from previous investigations were compared first to the Corps-recommended levels for arsenic, barium, cadmium, chromium, and lead (Corps 1994). Where recommended background values were unavailable, metals concentrations from previous investigations were initially compared to levels found in Alaskan soils (Gough 1988) and in soils of the western United States (Shacklette 1984).

1.1.1 Landfill Source Area

1.1.1.1 Location and Physical Setting

The Landfill Source Area includes Fort Wainwright's active landfill, north of River Road, and the area immediately south of River Road, which was identified as containing trenches in 1972 aerial photographs (see Figure 1-2). The Landfill serves Fort Wainwright only; the Fairbanks North Star Borough operates a separate public landfill for the borough. For descriptive purposes, the active landfill will be referred to as the Landfill and the area south of River Road will be called the Former Trench Area.

The Landfill Source Area is approximately 1 mile north of Fort Wainwright's Main Cantonment Area and approximately 1,500 feet north of the Chena River. It covers approximately 60 acres (40 acres north of River Road and 20 acres south of River Road) at an elevation of approximately 440 feet above mean sea level (MSL) with level topography (Woodward-Clyde Consultants [WCC] 1990). Birch Hill, north of the source area, rises to 1,100 feet above MSL. Wetlands border the Landfill to the north and east, and a black spruce forest borders the remainder of the source area, except in areas cleared for access to the Landfill, along River Road. The Landfill Source Area is underlain by discontinuous permafrost.

Two aquifers were targeted for investigation during field activities: a shallow, near-surface aquifer (suprapermafrost aquifer) and a deeper, semiconfined or confined aquifer (subpermafrost aquifer). Discontinuous permafrost is in the subsurface and affects the direction and velocity of groundwater flow. The predominant groundwater flow direction in the shallow and deep aquifers is to the west-southwest. Surface water is in small ponds to the north, east, and west of the Landfill. The main overland surface water pathways to the Chena River are drainages from the southeast and southwest corners of the Landfill.

The Landfill is operating under State of Alaska Permit No. 9131-BA007. The height of the Landfill averages 50 feet above grade, with higher portions near the working face (Fosbrook 1993). Landfill disposal activities were ongoing during the RI. Refuse disposal areas were designated toward the northwest and north sections of the Landfill, near the elevated northern edge of the Landfill embankment. Coal ash piles were stored along the south end of the Landfill, near the entrance. Linear northwest-to-southeast-trending, backfilled refuse berms, 10 to 15 feet high, were evident within the active backfill area.

The Former Trench Area (see Figure 1-2) south of River Road is covered by an approximately 20-year-old mixed, hardwood/spruce forest. Gravel quarry pits border the Former Trench Area on the west side. The trenches were not visible in June 1971 aerial photographs but were identified in September 1972 aerial photographs, which suggests that they were created in late 1971 or early 1972. Signs previously posted in the area read, "Covered Wet Garbage Trenches" (Short 1993). However, little is known about the supposed burial activities in the Former Trench Area.

1.1.1.2 Past Practices

Gravel excavation began in the Landfill area as early as 1944. Landfill operations reportedly began in the 1950s; however, no historical records documenting a start date exist. Waste was disposed in the gravel pits, estimated to be 8 to 10 feet deep, and then burned. After the gravel pits were filled with burned debris, they were covered. Aerial photographs indicate that the Landfill was expanded in the late 1950s and early 1960s. It became the only active landfill in Fort Wainwright's Main Cantonment Area in the late 1950s and began receiving all wastes generated at the fort, except chemical warfare or radioactive materials. The waste included small quantities of human waste; household refuse; waste petroleum, oil, and lubricants (POLs); hazardous waste; pesticides; asbestos; construction debris; and inert

munitions (Kerns 1992a). The human waste was and continues to be disposed of in the western portion of the Landfill. A 1966 aerial photograph shows trenching or clearing on the Landfill's east side. Other aerial photographs indicate that new trenches were dug on the northwest and possibly on the east side of the Landfill in 1972. Specific types of materials disposed of in these trenches are unknown (Kerns 1992a).

Sometime in the 1960s, waste disposal practices shifted from trenching and burning to spreading waste on the ground surface and compacting it (Kerns 1992a; Fosbrook 1993). Landfill wastes historically were covered with a 12- to 15-inch layer (lift) of coal ash from the Fort Wainwright power plant, and each lift was compacted by bulldozer. The coal ash was pushed over the working face from the top of the lift. The current permit mandates that all loose refuse be consolidated, compacted, and covered with at least 6 inches of compacted soil at least once each operating day (ADEC 1991).

Previous investigations documented known waste practices and wastes known or suspected to have been disposed of at the Landfill. A 1983 United States Army Environmental Hygiene Agency (AEHA) study estimated that at the time of its investigations, 7.7 tons of solid waste were being generated per day, or approximately 8,000 cubic yards per year (AEHA 1983). A 1983 Environmental Services and Engineering (ESE) report states that the practice of the day was to dispose of 4.5 kilograms per day (kg/day) or 1,642.5 kilograms per year (kg/year) of dry cleaning waste filter (reportedly redistilled before disposal to remove perchloroethylene) and less than 189 liters per year of vehicular paint waste. Asbestos was bagged and disposed in a separate cell on the east side of the Landfill. During ESE's 1983 site visit, some bags containing asbestos were open and subject to wind dispersal. The 1983 ESE report states that small-arms and explosives disposal at the Landfill rarely occurred. In addition, triple-rinsed punctured and crushed pesticide cans, and rags and soil from small pesticide spills, were disposed of at the Landfill at the time of the ESE report (ESE 1983).

In addition, the Landfill reportedly received drums and debris from the Utilidor Expansion Drums site (OU-1); paint debris from Building 2077 (OU-1); more than 1,000 empty drums and two fuel tanks from the Blair Lakes Drums site (OU-1); approximately 1,000 drums of excavated material from the Glass Park Tar site (OU-2); and the remnants of Building 2250, the Golf Course Pesticide Shed (OU-1; Harding Lawson Associates [HLA] 1992; Kerns 1992b, 1992c). Construction debris was used to make cells throughout the Landfill.

The current landfill permit allows disposal of only domestic and commercial refuse, ash, asbestos, incinerator residue, bagged human waste, and construction or demolition waste (ADEC 1991). The intent of this RI was only to investigate the potential environmental impact to soil and groundwater from past practices and not to investigate current landfill operations.

1.1.1.3 Previous Investigations

Investigations began at the Landfill in 1976, when the Corps installed four well points around the Landfill to support a solid waste study. The analytical results from this sampling effort contain numerous discrepancies that could not be resolved during this project. As a result, the data will not be reported here.

In 1983, AEHA conducted an evaluation of solid waste disposal practices at the Landfill. Recommendations listed in this report included the need for routine groundwater monitoring and the need to grade and cover the side slopes of the Landfill to eliminate exposure of solid waste (AEHA 1983).

Hart Crowser installed three shallow wells (FWLF-2, FWLF-3, and FWLF-4), approximately 20 to 25 feet BGS, at the Landfill in early 1984. Since 1985, these wells have been sampled periodically and analyzed for organic and inorganic parameters. Also in 1985, an existing production well at the Birch Hill Ski Area was sampled to obtain background concentrations (FW-1); however, because it is screened in a different aquifer from the Landfill wells, analytical results did not represent true background conditions. In May and November 1985, samples from FWLF-2 and FWLF-4 contained concentrations of endrin, toxaphene, and lead above the former State of Alaska drinking water maximum contaminant levels (MCLs) of 0.0002 milligrams per liter (mg/L), 0.005 mg/L, and 0.05 mg/L, respectively (WCC 1990). Manganese was detected above the secondary MCL of 0.05 mg/L. The 1985 analytical results for endrin and toxaphene were qualified as estimated because the reported quantities were less than the detection limits and detection limits were above the MCLs.

In 1988, Woodward-Clyde Consultants (WCC) conducted an electromagnetic (EM) survey to define the Landfill's west edge and to clear a site for upgradient wells on the Landfill's east side. Three wells (W-LF-01, W-LF-02, and W-LF-03) were installed and sampled. Sample analytical results revealed manganese above the secondary MCL of 0.05

mg/L (WCC 1990). WCC personnel also conducted an aquifer test using these wells, and they estimated that the transmissivity of the aquifer in the area of the Landfill was 100,000 to 300,000 gallons per feet per day (gal/feet/day) and that the specific yield was 0.07 to 0.56 (unitless).

In 1989, E & E conducted an EM survey to evaluate the apparent terrain electrical conductivity of the shallow aquifer system, to locate potential leachate plumes associated with the Landfill, and to investigate disturbed areas that may contain buried wastes. Patterns of low conductivity were found to be related to permafrost (less than 1 millimhos/meter [mmho/m]). Elevated conductivity readings (maximum of 5.1 mmho/m) were attributed to a shallow water table and the proximity of overhead power lines, not a leachate plume. The conductivity in potential plume areas was not found to be significantly different than in known uncontaminated areas.

In 1990, E & E conducted a sampling investigation in which boreholes were drilled; monitoring wells were installed; and surface soil, subsurface soil, groundwater, surface water, ash, and sediment samples were collected (E & E 1991). The analytical results are summarized as follows.

Composite ash samples from the coal ash Landfill cover contained metals at high concentrations. Arsenic was detected in one ash sample at a concentration (22 milligrams per kilogram [mg/kg]) exceeding the recommended background level for arsenic in soils north of the Chena River (17 mg/kg [Corps 1994]). Barium concentrations in all ash samples exceeded the recommended background value for soil (275 mg/kg). The barium concentrations (4,100 to 6,418 mg/kg) were potentially a concern because they exceeded the risk-based concentration (RBC) of 0.52 micrograms per cubic meters (μ g/m³) for ambient air, which could pose a health risk to landfill workers; however, the concentration of barium in ambient air was not measured. Copper concentrations in all ash samples exceeded the normal range for copper in western United States soils (E & E 1991; Shacklette 1984).

None of these metals exceeded federal maximum allowable level using the extraction procedure (EP) toxicity limits (E & E 1991). Although the EP toxicity test is no longer used, it is comparable to toxicity characteristic leaching procedure (TCLP).

Surface and near-surface soils contained volatile organic compounds (VOCs) and metals. Surface soils on the Landfill's west side contained levels of barium (752 to 4,380 mg/kg) above the recommended background values for soils north of the Chena River (275

mg/kg; Corps 1994; E & E 1991). The concentrations of cadmium (2.7 to 3.8 mg/kg) in near-surface soil samples collected from shallow boreholes at various locations around the Landfill were higher than the recommended background value for cadmium in soils north of the Chena River (1.7 mg/kg; Corps 1994; E & E 1991). Toluene (9 micrograms per kilogram [μ g/kg]) and tetrachloroethane (estimated at 7 μ g/kg) were detected in two different surface soil samples (E & E 1991). Background soil samples were not collected.

Subsurface soils also were found to contain VOCs and metals on the Landfill's west and south sides. The highest concentrations of VOCs (83 μ g/kg 1,2-dichloroethene; 45 μ g/kg trichloroethene; and 2 μ g/kg toluene) in subsurface soils were detected in a borehole sample (AP-5589) at a depth of 20 feet southwest of the Landfill. Metals concentrations were similar in all subsurface soils from various areas around the Landfill. In general, metals were detected in the average range for Alaska soils (E & E 1991; Gough 1988). Mercury was detected in subsurface soil near the Former Trench Area at 0.22 mg/kg, which is higher than the normal western United States soil range (0.02 to 0.11 mg/kg; E & E 1991; Shacklette 1984). The concentration of cadmium (2.6 mg/kg) in one subsurface soil sample was higher than the recommended background value of 1 mg/kg (Corps 1994; E & E 1991).

VOCs were detected in groundwater samples from wells in a permafrost-free area in the Landfill's southwest corner and on its east side. Contaminant concentrations were greatest in shallow well AP-5588 (E & E 1991). Table 1-1 lists the VOCs found in groundwater samples collected at the Landfill during the 1990 investigation and subsequent sampling events.

Most metals concentrations were below the then-current state and federal primary MCLs, except for arsenic, detected at concentrations of 0.062 mg/L (MCL 0.05 mg/L), and cadmium, detected at concentrations of 0.007 and 0.011 mg/L (MCL 0.005 mg/L). However, these analytes did not exceed the recommended background levels for arsenic and cadmium in groundwater for Fort Wainwright (0.072 and 0.009 mg/L, respectively; Corps 1994). Every groundwater sample contained iron and manganese in excess of state and federal secondary MCLs (iron: 0.3 mg/L and manganese: 0.05 mg/L).

Surface water from wetlands surrounding the Landfill contained metals and low levels of pesticides. One surface water sample contained 0.06 micrograms per liter (μ g/L) DDE and 0.05 μ g/L endosulfan. The concentration of DDE is significantly lower than the lowest observed effect level (LOEL) for DDE (1,050 μ g/L) used by the State of Alaska as a fresh-

water quality criterion (18 AAC 70). However, the level of endosulfan is comparable to the Alaska water quality criterion of 0.056 μ g/L (24-hour average). One surface water sample contained silver at a concentration (0.06 mg/L), which exceeded the Alaska water quality criterion LOEL for silver in fresh water (0.12 μ g/L). All surface water samples contained iron and manganese concentrations that exceeded the state and federal secondary MCLs for drinking water (iron: 0.3 mg/L and manganese: 0.05 mg/L). However, the concentration of iron is significantly less than the Alaska water quality criterion for iron in fresh water (1,000- μ g/L); there is no published criterion for manganese). No background surface water samples were collected (E & E 1991; ADEC 1991).

Sediments from one of the wetland areas contained barium (2,490 mg/kg) at a concentration that exceed recommended background levels (E & E 1991; Corps 1994). No background sediment samples were collected.

The Corps sampled groundwater wells at the Landfill in 1991 and 1992. VOC analytical results are summarized in Table 1-1 because these have historically been the main contaminants of concern. Common laboratory contaminants have not been included. As in the 1990 investigation, the highest concentration of VOCs was found in well AP-5588, the shallow well in the drainage swale southwest of the Landfill. The levels of trichloroethene were consistently above the MCL of 5 μ g/L in wells AP-5588 and AP-5589. Benzene was detected above the MCL of 5 μ g/L in well AP-5589 during each sampling event. The level of 1,2-dichloroethene (total) in well AP-5588 varied during sampling events from levels above the combined MCLs to below the MCLs. The concentration of trichloroethene in well AP-5594 on the Landfill's east side exceeded the MCL of 5 μ g/L in the April 1990 sampling event (Corps 1992b). In subsequent sampling events, MCLs for VOCs have been exceeded only in samples collected from the wells in the drainage swale southwest of the Landfill.

No base/neutral and acid extractable organic compounds (BNAs) or pesticides/polychlorinated biphenyls (PCBs) were detected in the 1991 groundwater samples. Iron and manganese were detected at concentrations above secondary MCLs in each well for both sampling events. These samples were not analyzed for total petroleum hydrocarbons (TPH).

Groundwater samples were not analyzed for petroleum in 1990 and 1991. In April 1992, diesel was detected in AP-5585 (0.128 mg/L) and AP-5595 (0.210 mg/L) wells south of Birch Hill Road. In September 1992, diesel was detected in most wells surrounding the Landfill ranging in concentrations from 0.105 mg/L to 1.18 mg/L.

1.1.1.4 Potential Sources

In addition to the contaminant sources that may exist within the Landfill, the upgradient potential sources of contamination include:

- Fairbanks-Eielson Pipeline (FEP). This pipeline runs from the Tank Farm (OU-3) to Eielson Air Force Base (AFB). The only portion of the pipeline still in operation is from the Mapco Refinery to Eielson AFB; and
- Building 1172. Two leaking underground storage tanks (USTs) were removed from the ski lodge and were used to store diesel and gasoline. The tanks were removed in July 1991. Remediation of groundwater was unnecessary, but monitoring for BTEX and DRO continues under a separate investigation.

1.1.2 Coal Storage Yard Source Area

1.1.2.1 Location and Physical Setting

The CSY is west of Meridian Road, south of the Fort Wainwright power plant, and east of the power plant's cooling pond (see Figure 1-3). The power plant is a coal-fired cogeneration plant, supplying electricity and steam to Fort Wainwright. The CSY is used to stockpile supplies of coal before burning.

The CSY is located within an industrial portion of the Main Cantonment Area and is bounded to the west by the cooling pond, to the north by the power plant building, to the south by an unnamed road, and to the east by a small hill. The CSY Source Area includes the active coal pile, the cooling pond area, and a fenced storage area. Within the fenced storage area are three USTs; the USTs were investigated under the two-party agreement. In 1994, three monitoring wells were installed adjacent to the USTs to monitor potential groundwater contamination associated with the UST. The main area of concern at the CSY is the northern half of the active coal pile, where waste fuels and solvents reportedly were applied to the coal pile. Petroleum-contaminated soil stockpiles were located in an area between the CSY and Meridian Road. The stockpiles were incinerated in summer 1993.

The areas north and east of the CSY are sparsely vegetated, while the areas to the south and west have mixed hardwood forests. Surface water runoff from the CSY is believed to flow through a series of swales, channels, and ditches and eventually into the Chena River, approximately 1,000 feet north-northwest of the source area. Unconsolidated saturated sand and gravel fluvial deposits underlie the surficial layer at the CSY. No permafrost has been

identified. Groundwater in wells completed in the CSY area was encountered at 4 to 12 feet below ground surface (BGS; Corps 1986). Based on the fortwide groundwater monitoring network, groundwater beneath the CSY flows to the west-northwest toward the Chena River and is consistent with the regional groundwater flow direction south of the Chena River at Fort Wainwright (Corps 1992b).

1.1.2.2 Past Practices

Coal was stored directly on the ground in the CSY; no liner was used. Waste POLs, such as diesel, fuel oil, lubricants, and antifreeze compounds, were spread over the coal to increase the British thermal unit (BTU) content and the power plant's output. The application of fuels to the coal pile has ceased (Levine 1992; Short 1993). As each pile of coal was utilized in the power plant, the underlying soils and coal (approximately 12 inches) were graded, collected, and burned in the power plant. A new layer of soil and coal then was added to the surface of the CSY, and the process was repeated.

1.1.2.3 Previous Investigations

In 1986, the Corps installed nine monitoring wells (AP-5505, AP-5506, AP-5507, AP-5508, AP-5509, AP-5510, AP-5511, AP-5512, and AP-5513) in the CSY vicinity. Wells AP-5507 and AP-5513 were destroyed in coal moving activities. Coal ash, coal, and sands were identified in borings AP-5508 and AP-5509 in the interval 2.5 to 6 feet BGS.

Soil and water samples were collected at each drilling location. Analyses included oil and grease; certain metals; halogenated VOCs; benzene, toluene, ethylbenzene, and total xylenes (BTEX); pesticides; and PCBs.

Oil and grease concentrations in soils ranged from 262 to 1,676 mg/kg. Generally, the highest concentrations were detected in near-surface soils. The oil and grease analytical method was a previously used EPA method that did not exclude natural occurring oils and greases. This method is not comparable to EPA Method 418.1 or Corps of Engineers Modified EPA Method 8015. Pesticides were detected in several near-surface soil samples from AP-5507 (0.0077 mg/kg DDT), boring AP-5510 (0.051 mg/kg DDT and 0.007 mg/kg DDE), and boring AP-5506 (0.0061 mg/kg DDT). Benzene and trichloroethene were the only VOCs detected in soil samples. The concentration of benzene was 0.072 mg/kg in a soil sample collected between 4 feet BGS and 5.5 feet BGS in boring AP-5509 and 0.058 mg/kg

in a soil sample collected between 0 foot and 1.5 feet BGS in boring AP-5507. Trichloro-ethene was detected at a concentration of 0.026 mg/kg in a duplicate soil sample collected between 4.5 and 6 feet BGS in boring AP-5505. BNA analyses were conducted on one soil sample; no BNAs were detected (Corps 1993). The concentrations of antimony (0.22 to 1.01 mg/kg) and mercury (0.02 to 0.11 mg/kg) were generally higher at all depths than the normal range for those metals in the western United States (Shacklette and Boerngen 1984). No concentration ranges are available for these metals in Alaska soils (Gough *et. al* 1988).

Groundwater samples were collected only from wells AP-5506, AP-5508, AP-5510, and AP-5512. No halogenated VOCs were detected. BNA analyses were conducted only on the groundwater sample collected from well AP-5506; phenol was detected at a concentration of 0.003 mg/L. No MCL for phenol is available. The concentration of cadmium detected in groundwater samples from wells AP-5508 and AP-5512 was at the MCL of 0.005 mg/L (18 Alaska Administrative Code [AAC] 80.070). The recommended background value for cadmium in groundwater at Fort Wainwright is 0.009 mg/L (Corps 1994). Concentrations of antimony, nickel, and thallium exceeded the MCLs of 0.006 mg/L, 0.1 mg/L, and 0.002 mg/L, respectively, for those metals (Corps 1993; 18 AAC 80.070).

In June 1991, the Corps again sampled groundwater from the seven remaining monitoring wells (AP-5505, AP-5506, AP-5508, AP-5509, AP-5510, AP-5511, and AP-5512) at the CSY and analyzed the groundwater for TPH, Resource Conservation and Recovery Act (RCRA) metals, total organic halides (TOX), pesticide/PCBs, and aromatic volatile compounds. The groundwater samples were analyzed for TPH by EPA Method 418.1. Concentrations of TPH ranged from not detected at 0.2 mg/L to 0.6 mg/L. No petroleum hydrocarbons were detected by EPA Modified Method 8100, except for 0.103 mg/L in one of three replicate samples. RCRA metals were identified, but concentrations did not exceed MCLs. Groundwater samples analyzed for TOX had concentrations ranging from not detected at 10 mg/L to 38 mg/L. Groundwater samples analyzed for pesticides/PCBs had 4-4'-DDD at 0.000718 mg/L in AP-5512; endrin at 0.000687 mg/L in AP-5512; and endrin aldehyde at 0.000768 and 0.000437 mg/L in wells AP-5505 and AP-5510, respectively (Corps 1991a). The concentration of endrin did not exceed its MCL of 0.002 mg/L; no MCLs are available for the other compounds (18 AAC 80.070). No aromatic volatile compounds were detected by EPA Method 8020 in any of the groundwater samples.

Surface soil contamination associated with darkly stained areas in the CSY also was reported during the June 1991 groundwater sampling event. Organic vapor readings from 0 to 150 parts per million (ppm) were recorded using a photoionization detector (PID; Corps 1991a). The stained soil subsequently was burned in the power plant (TeVrucht 1993). A 500-gallon diesel and Mogas spill also was reported in the north portion of the CSY in 1991 (ADEC 1991).

AEHA investigated surface soil contamination at the CSY from July to August 1991 as a result of a Notice of Violation from ADEC, which alleged violations of the Alaska Oil Pollution Regulation Act 18 AAC 75.080 and the State of Alaska Hazardous Waste Regulation No. 18 AAC 62.410(3). AEHA sampled soil within the active coal pile, along the road adjacent to the cooling pond, and other locations not included in the source area. Coal samples also were collected and collocated with a portion of the surface soil samples collected. Water samples were collected from the intake and outlet of the cooling pond (AEHA 1991).

Surface soils within the center of the active coal pile contained the highest concentrations of semivolatile organic compounds (SVOCs), VOCs, and TPH. Concentrations of SVOCs ranged from 4.3 to 16 mg/kg of 2-methylnaphthalene and 4.5 to 12 mg/kg of naphthalene. Concentrations of VOCs are summarized on Table 1-2. Again, samples in the center of the active coal pile contained the highest concentration of VOCs. Soils collected along the road adjacent to the cooling pond contained 1,1,1-trichloroethane from 0.012 to 0.048 mg/kg, and petroleum hydrocarbons from the detection limit of less than 0.010 to 38 mg/kg. The highest concentrations were detected in the center of the working area and on the road adjacent to the cooling pond. Barium (42 to 1,800 mg/kg), chromium (13 to 25 mg/kg), and lead (22 to 41 mg/kg) in soil samples from the CSY exceeded the Corpsrecommended background values for these metals in soils south of the Chena River (i.e, 115 mg/kg for barium, 19 mg/kg for chromium, and 26 mg/kg for lead; Corps 1994).

Water samples from the cooling pond were analyzed for petroleum hydrocarbons and metals. Petroleum hydrocarbons were not detected at the detection limit of less than 1 mg/L. Barium and lead were detected in the water samples but did not exceed Alaska water quality criteria.

Coal samples were analyzed for metals. Arsenic concentrations ranged from 1.3 to 2.3 mg/kg, barium concentrations ranged from 320 to 430 mg/kg, and chromium concentra-

tions ranged from 5.3 to 7.2 mg/kg. Concentrations of arsenic and chromium in the coal generally were less than those in the associated soil samples.

In 1991, the Corps conducted a UST investigation at eight locations on Fort Wainwright, including an area near and in the CSY. Three wells were installed: one adjacent to the active coal pile (well AP-5736) and two upgradient of the CSY (wells AP-5734 and AP-5735) near the contaminated soil piles.

Soil samples from these locations were analyzed for total recoverable petroleum hydrocarbons (TRPH), fuel identification (fuel ID), halogenated VOCs, and TCLP lead. The sample collected at 15 feet BGS from boring AP-5736 contained 120 mg/kg TRPH by Corps of Engineers Modified 8015. No fuel was identified in this sample. Two samples from boring AP-5734 contained detectable levels of TRPH (48 mg/kg in a duplicate sample collected at 5 feet BGS and 45 mg/kg in a sample collected at 10 feet BGS). No other soil samples contained detectable concentrations of TRPH. The soil sample collected at 15 feet BGS from boring AP-5736 contained 12 mg/kg diesel-range organics (DRO). The sample collected at 10 feet BGS from boring AP-5736 contained toluene at 0.028 mg/kg. No other VOCs were detected. Only two samples were analyzed for TCLP lead, and the concentrations were below the TCLP lead criterion of 5 mg/L (Corps 1992c).

Groundwater samples were analyzed for POLs, BTEX, VOCs, pesticides/PCBs, and RCRA metals. DROs were detected at 44 μ g/L in well AP-5736. No other fuel or fuel constituent was detected. The water samples did not contain detectable concentrations of TRPH, pesticides/PCBs, or BNAs. VOCs were detected in groundwater samples, but the same analytes also were detected in the trip or method blanks. Aside from the common laboratory contaminants, VOCs detected included 1,1-dichloroethene ranging from 0.0076 to 0.014 mg/L in wells AP-5734, AP-5735, and AP-5736 (MCL: 0.007 mg/L); 1,1,1-trichloroethane ranging from 0.0004 to 0.0023 mg/L in wells AP-5734 and AP-5735 (MCL: 0.2 mg/L); and xylenes at 0.0002 mg/L in well AP-5735 (MCL: 10 mg/L; 18 AAC 80.070). No 1,1-dichloroethene or 1,1,1-trichloroethane was detected at detection limits of 0.0001 mg/L in duplicate samples. Xylenes were detected in one of three replicate samples and in the trip blank. No metals were detected above MCLs (Corps 1992; 18 AAC 80.070).

Bituminous coal was found from the surface to 3 feet BGS in boring AP-5735 and from the surface to 4.5 feet BGS in boring AP-5736. No coal was found in boring AP-5734. Permafrost was not encountered in any of these borings, but groundwater was encountered

between 13.5 feet BGS and 17 feet BGS. Generally, the subsurface lithology of these borings consisted of poorly graded sand with silt to silt with gravel or silt with sand (Corps 1992c).

1.1.2.4 Potential Sources

In addition to the contaminant sources characterized for this RI, the upgradient potential sources of contamination at the CSY include:

- The wooded area south of the CSY. Several asphalt piles were found throughout the woods. Additional waste may have been deposited;
- The roadways and ditches south and southeast of the CSY; and
- The railway south of the CSY.

1.1.3 Fire Training Pits Source Area

1.1.3.1 Location and Physical Setting

The FTPs Source Area is in the Main Cantonment Area, approximately 300 feet south of Montgomery Road near the southeast corner of the runway. The source area is less than 1 mile south of the Chena River and 3 miles north of the Tanana River (see Figure 1-4).

The main areas of concern within the FTPs Source Area are the cleared area surrounding FTP-3A, the cleared area surrounding FTP-3B, and a depression immediately north of the access road between FTP-3A and FTP-3B. FTP-3A is within a large, cleared grassy area surrounded by trees and is bounded on its northeast corner by a gate restricting vehicular traffic. A row of charred cars and trucks lines the west edge and a portion of the north edge of the cleared area. An aboveground water tank is in the northeast corner, and empty USTs line the east edge of the cleared area. FTP-3A consists of an approximately 50-foot-diameter area of black stained soils. Small areas of stained soils exist throughout the cleared area.

The FTP-3B cleared area is 7.5 acres and is in a depression that is approximately 1 to 3 feet lower than the surrounding forest. The southern third is vegetated with saplings and grass. The northern two-thirds of the FTP-3B cleared area are covered with gravel and grass. FTP-3B is a 5- to 10-foot-diameter area filled with gravel and small pieces of concrete.

The depression north of the access road between FTP-3A and FTP-3B is approximately 2 feet lower than the surrounding woods. An approximately 6-foot-diameter area of

stained soil is in the northwest portion of the depression. A 3-foot-diameter area of stained soil is on the depression's eastern edge. Cans were scattered around the larger stained area.

Aside from the FTPs themselves, the surfaces of the cleared areas surrounding the FTPs are level with the surrounding ground surface. The FTPs do not have surface water runoff diversion systems (E & E 1991). The FTPs Source Area is underlain by discontinuous permafrost.

1.1.3.2 Past Practices

The FTPs were used for training of fire department and rescue crews. Fire training activities at FTP-3A began in the late 1970s; the pits were closed in 1988. The exact year in which training activities began at FTP-3B is unknown but occurred sometime after 1967 (E & E 1990). Use of this FTP most likely terminated when activities at FTP-3B began. Flammable liquids were containerized and stored at the various FTP subareas and were burned during fire extinguishing training exercises.

The sequence of activities for FTP exercises generally included soaking FTP soils with water; filling the FTP with fuels, brake fluid, and solvents; igniting the flammable mixture; and extinguishing the resultant fire. The fuels typically included diesel, JP-4, and waste oil. Solvents also may have been added to the waste oil. When constructed, the bottoms of the FTPs were not lined with impervious materials. It was estimated that 1,500 to 2,300 gallons of flammable liquids were burned per year in the FTPs (Corps 1989).

1.1.3.3 Previous Investigations

In 1986, AEHA investigated FTP-3A. Seventeen surface and subsurface soil samples were collected from three boreholes in the FTP. These samples were analyzed for VOCs, metals, extractable organics, BNAs, and pesticides. The only analyte detected was bis(2-ethylhexyl)phthalate, a common laboratory contaminant. The concentrations of this analyte ranged from 1 to 17 ppm. Holding times for VOCs and other analyses were exceeded, and it was recommended that additional sampling be conducted (AEHA 1986).

In 1988, a soil gas survey was conducted at FTP-3A to establish the extent and distribution of hydrocarbons and VOCs in the shallow subsurface. Sixteen soil gas probes were driven to a maximum depth of 20 feet. Fifty-two soil gas samples were collected. Benzene, toluene, and xylenes were detected at maximum concentrations of 1,600 parts per

million by volume (ppmv), 5,400 ppmv, and 310 ppmv, respectively, in probes within the FTP (WCC 1990). Other unidentified hydrocarbons also were detected. Two groundwater samples were collected through a probe driven into the groundwater. One sample contained acetone at 3,700 μ g/L, and the other sample contained dichlorofluoromethane at 26 μ g/L. In general, benzene, toluene, and xylenes concentrations decreased significantly with distance from FTP-3A. The soil gas survey indicated that contamination at FTP-3A is localized.

In June 1991, E & E investigated FTP-3A and FTP-3B. FTP-3A surface soil contained diesel-range hydrocarbons at concentrations (21,460 mg/kg) that exceeded the ADEC cleanup matrix Level A concentration. Additional contaminants detected in FTP-3A surface soil included benzene (0.421 mg/kg), toluene (1.611 mg/kg), xylenes (2.205 mg/kg), and lead (99.3 mg/kg). The concentration of BTEX in this sample did not exceed ADEC cleanup matrix guidelines of 10 ppm. Analyses of subsurface soil from FTP-3A did not reveal contamination.

FTP-3B also contained diesel-range hydrocarbons from 2.5 to 8.5 feet BGS at concentrations (1,370 to 1,707 mg/kg) that exceeded the ADEC cleanup matrix Level B concentration. Subsurface soil samples from FTP-3B contained xylenes (1.167 mg/kg) and 2-methyl-naphthalene (1.47 mg/kg) from 2.5 to 4 feet BGS. The level of BTEX in this borehole did not exceed the ADEC cleanup matrix guideline for BTEX.

1.1.3.4 Potential Sources

In addition to the contaminant sources characterized as part of this RI, the upgradient potential sources of contamination at the FTPs include:

- The N-4 site southeast of the FTPs;
- The DRMO and assorted Badger Road (Arctic Surplus) sites southeast of the FTPs;
- Clear Creek Subdivision USTs east-southeast of the FTPs;
- Unidentified contaminant sources in the wooded areas immediately upgradient of the FTPs; and
- Roads and ditches immediately upgradient of the FTPs.

Table 1-1

VOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER SAMPLES LANDFILL SOURCE AREA

 $(\mu g/L)$

OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Well	Contaminant	4/90 ^c	8/91	10/91	MCL ^a	4/92	9/92
AP-5585	Carbon disulfide 1,2-Dichloroethane	ND ND	0.2 0.2	ND(5) ND(5)	b 5	0.2B ND(0.1)	ND(0.5) ND(0.5)
AP-5588	Vinyl chloride Carbon disulfide 1,2-Dichloroethene (total) 1,1-Dichloroethane Benzene 1,2-Dichloroethane Trichloroethene 1,2-Dichloropropane Toluene 1,1,2-Trichloroethane Tetrachloroethene Ethylbenzene Total xylenes 1,1,2,2-Tetrachloroethane	ND ND 470 ND 5 ND 250 ND ND ND ND ND ND	1.1 0.1 338.5 0.4 2.9 0.4 244 2.7 0.1 14 2.1 0.2 0.4 1,960	ND(5) ND(5) 60 ND(5) ND(5) ND(5) 220 ND(5) ND(5) ND(5) ND(5) ND(5) ND(5) ND(5)	2 b 170 b 5 5 5 5 1,000 5 700 10,000 b	2.6 ND(0.1) 450 ND(0.1) 4.5 ND(0.1) 240 ND(0.1) ND(0.1) 11.4 3.3 ND(0.1) ND(0.1) 1,100	1.2 ND(0.5) 282 0.6 3.7 3.2 210 ND(0.1) ND(0.5) ND(0.5) 2.5 ND(0.5) ND(0.5) 1,500E
AP-5589	Vinyl chloride Carbon disulfide 1,2-Dichloroethene (total) Benzene 1,2-Dichloroethane Trichloroethene 1,2-Dichloropropane 1,1,2,2-Tetrachloroethane	ND ND 29 6 ND 7 ND ND	1.9 0.2 19.4 6.7 4.2 5.6 0.4 1.0	ND(5) ND(5) ND(5) 6.7 ND(5) 5.8 ND(5) ND(5)	2 b 170 5 5 5 5	3 ND(2) 36.6 7.9 ND(0.1) 7.5 ND(0.1) ND(0.1)	1.5 ND(0.5) 23.9 5.6 5.2 5.3 ND(0.5) 1.8

Key at end of table.

Table 1-1

VOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER SAMPLES LANDFILL SOURCE AREA

(μg/L)
OPERABLE UNIT 4
FORT WAINWRIGHT, ALASKA

Well	Contaminant	4/90 ^c	8/91	10/91	MCLa	4/92	9/92
AP-5591	Carbon disulfide Benzene 1,2-Dichloroethane	ND ND ND	0.4 0.1 0.3	ND(5) ND(5) ND(5)	5 5	ND(0.1) ND(0.1) ND(0.1)	ND(0.5) ND(0.5) ND(0.5)
AP-5593	Benzene Toluene 1,2-Dichloroethane	ND 120 ND	0.1 ND(0.1) 0.8	ND(5) ND(5) ND(5)	5 1,000 5	ND(0.1) ND(0.1) ND(0.1)	ND(0.5) ND(0.5) ND(0.5)
AP-5594	Carbon disulfide Benzene 1,2-Dichloroethane Trichloroethene 1,1,2,2-Tetrachloroethane	ND ND ND 120 120	0.4 0.1 0.4 ND(0.1) ND(0.1)	ND(5) ND(5) ND(5) ND(5) ND(5)	b 5 5 5 b	ND(0.1) ND(0.1) ND(0.1) ND(0.1) ND(0.1)	ND(0.5) 8.8 ND(0.5) ND(0.5) ND(0.5)
FW-LF-1	Benzene	ND	0.1	ND(5)	5	ND(0.1)	ND(0.1)
FW-LF-2	Trichloroethene	ND	ND(0.1)	ND(5)	5	ND(0.1)	0.7
FW-LF-3	1,2-Dichloroethene (total) Benzene 1,2-Dichloroethane Trichloroethene 1,1,2,2-Trichloroethane Toluene	ND ND ND ND ND	0.3 0.1 0.3 0.1 2.5 ND(0.1)	ND(5) ^d ND ND ND ND ND	170 5 5 5 5 6	ND(0.1) ND(0.1) ND(0.1) ND(0.1) ND(0.1) ND(0.1)	ND(0.1) ND(0.1) ND(0.1) ND(0.1) ND(0.1) ND(0.1)
FW-LF-4	1,2-Dichloroethene (total) Benzene 1,2-Dichloroethane Toluene	ND ND ND 5	0.1 0.3 0.2 ND(0.1)	ND(5) ^d ND(5) ND(5) ND(5)	170 5 5 1,000	0.7 4.3 ND(0.1) ND(0.1)	0.5 2.4 ND(5.0) ND(5.0)

Key at end of table.

b There is no MCL for these compounds.

^C Detection limits were unavailable for this date.

d Detection limit is for trans-1,2-dichloroethene. Cis-1,2-dichloroethene was not reported.

Key:

MCL = Maximum contaminant level.

ND = Not detected.

 $\mu g/L = Micrograms per liter.$

^a MCLs are enforceable standards that apply to contaminants that the United States Environmental Protection Agency (EPA) has determined to have an adverse effect on human health above certain levels (EPA 1990).

Table 1-2

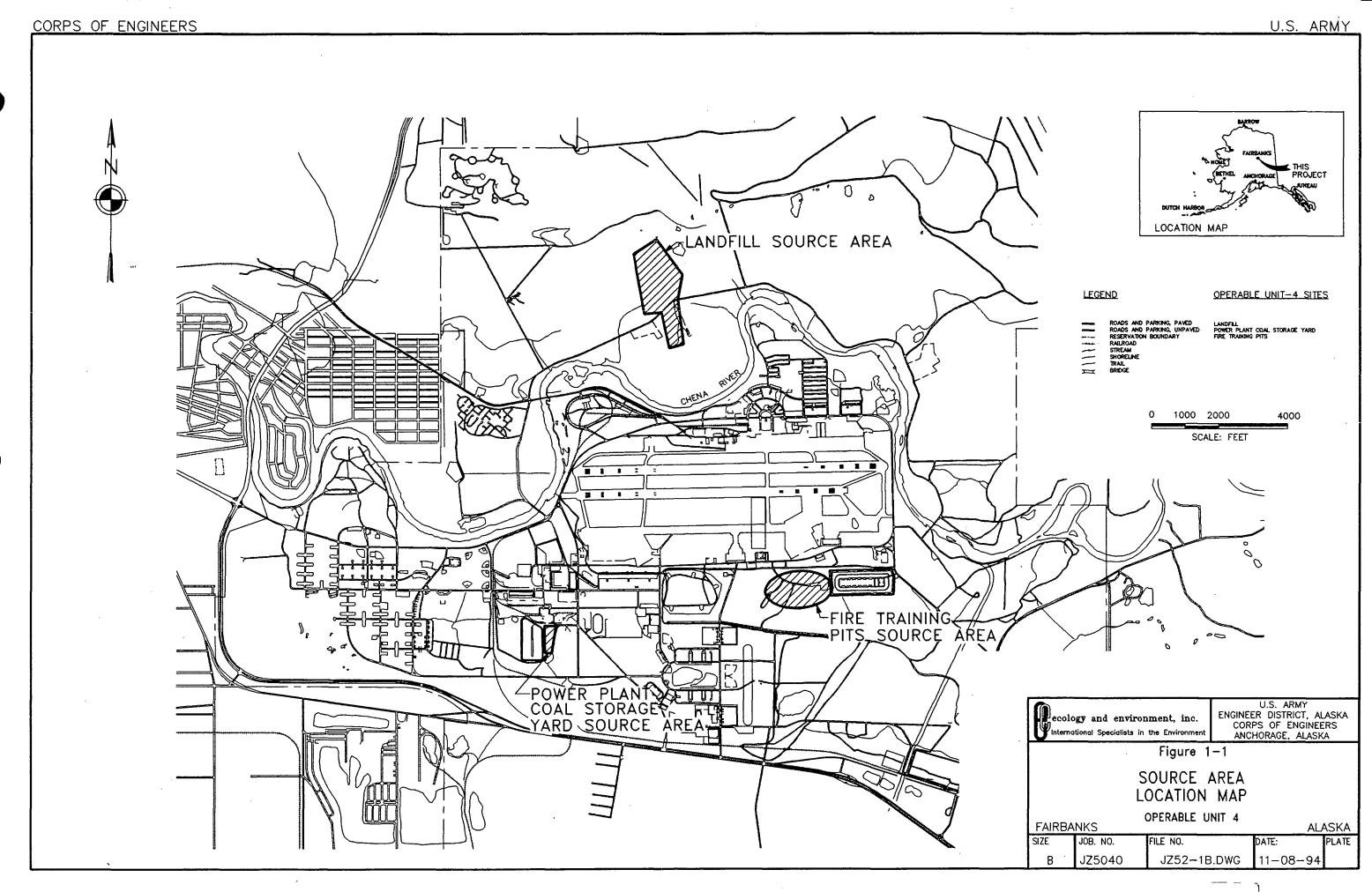
VOLATILE ORGANIC COMPOUNDS DETECTED IN SOIL SAMPLES FROM WORKING AREA OF COAL STORAGE YARD SOURCE AREA 1991 OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

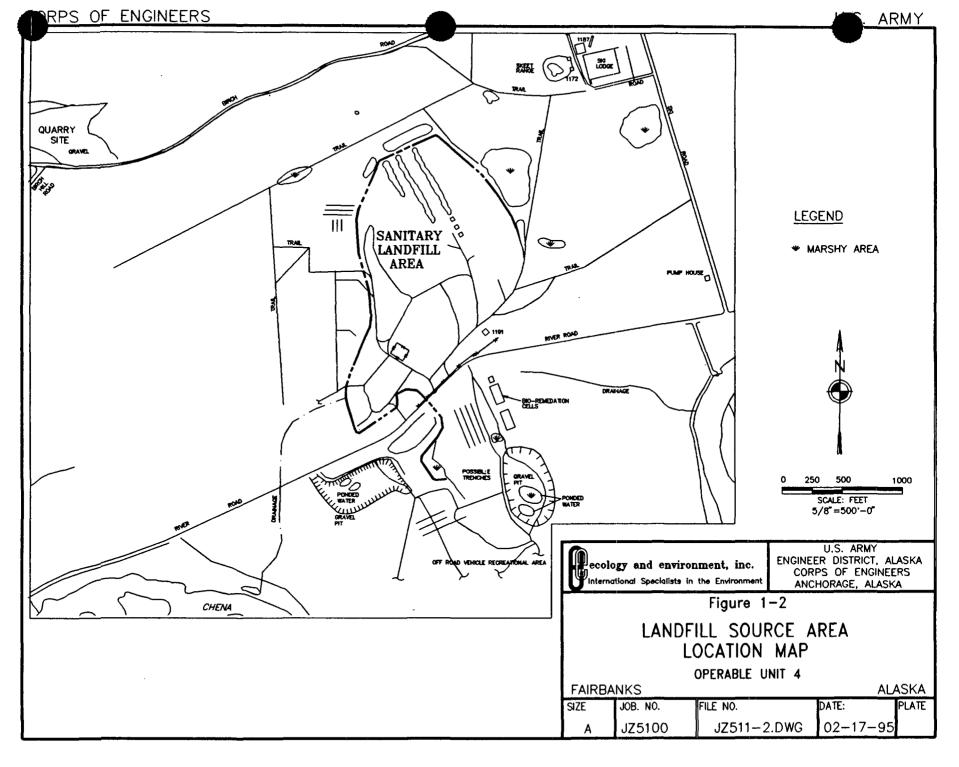
Range of Contaminant Concentration (mg/kg) 0.049 - 18 1,3,5-Trimethylbenzene 1,2,4-Trimethylbenzene 0.040 - 54 Ethylbenzene 0.024 - 31 sec-Butylbenzene 3.7 Isopropylbenzene 3.8 - 6.7 3.4 - 11 p-Isopropyltoluene 0.073 - 76 Toluene 0.93 - 51 o-Xylene m&p-Xylene 0.038 - 120

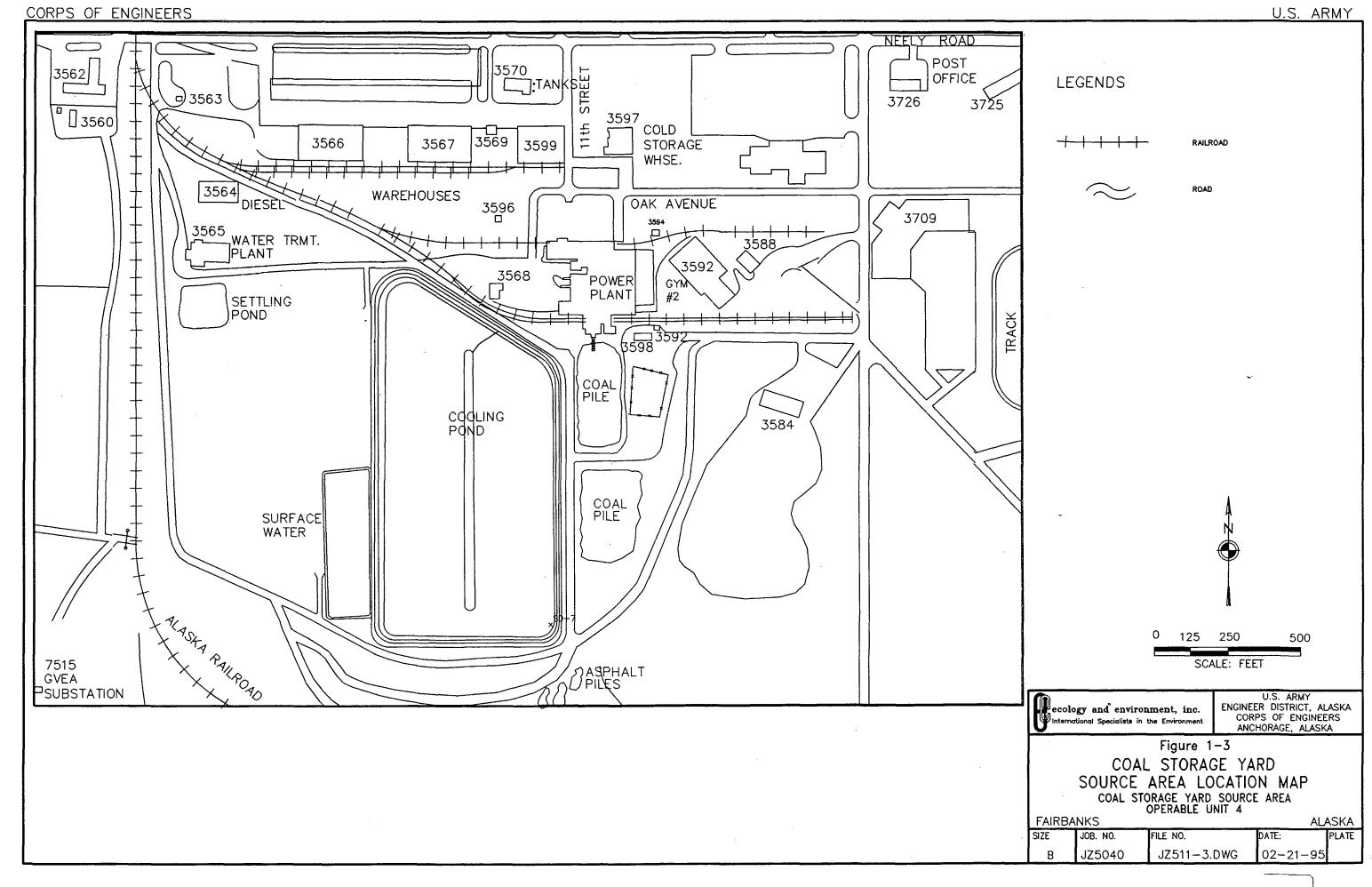
Source: United States Army Environmental Hygiene Agency 1991.

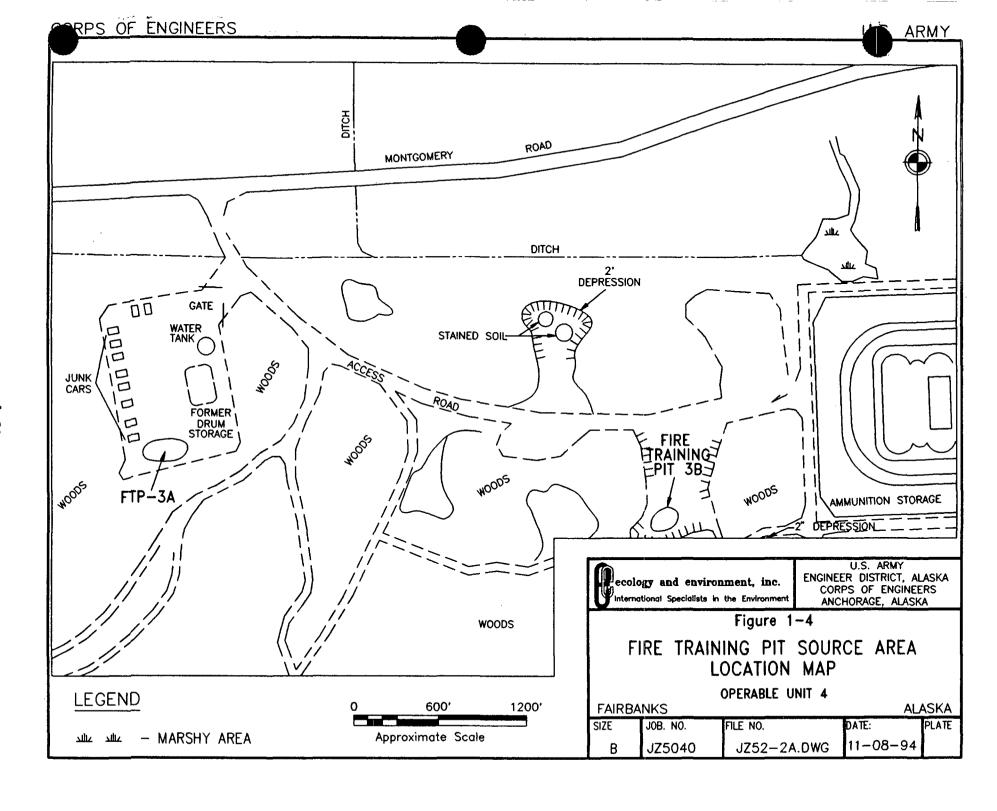
Key:

mg/kg = Milligrams per kilogram.









2. SOURCE AREA INVESTIGATIONS

The goal of the field investigation portion of the RI was to identify and characterize the presence and extent of contamination in soils, sediment, surface water, and groundwater at OU-4, and to evaluate contaminant migration in these media. The source area investigations were designed to fill data gaps regarding contaminant sources and distribution, as outlined in the conceptual site model (CSM) of the RI/FS Management Plan; provide the data required to complete a CERCLA risk assessment; evaluate remedial action alternatives; and supplement the present understanding of the source areas. This section briefly describes the objectives and methodologies of the key field tasks completed during the source area investigation, including:

- Geophysical survey;
- Field laboratory screening;
- Geoprobe[™] investigation;
- MicroWell sampling;
- Surface soil investigation;
- Surface water and sediment sampling from surface water bodies located in or adjacent to the source areas;
- Subsurface soil boring and sampling;
- Groundwater monitoring well installation and groundwater sampling;
- Aquifer testing; and
- Data collection for baseline ecological risk assessments.

Air monitoring at the Landfill was planned but not performed because of weather conditions. Instead of air monitoring, a modeling approach was completed and is discussed in the risk assessment.

As a fundamental part of the field program, a field laboratory was used to assist the field team in making informed decisions on potential sample locations. Additionally, some geophysical and geological information was obtained from the Corps' Cold Region Research and Engineering Laboratory (CRREL) and used to supplement the OU-4 geophysical data and site characterization and conceptualization. Boring logs from the Corps' 1994 subsurface investigation at the Landfill Source Area also were used as supplemental information to the OU-4 Landfill Source Area investigation.

2.1 GEOPHYSICAL INVESTIGATIONS

Geophysical investigations were conducted at the three source areas to characterize subsurface conditions and potential contaminant migration pathways.

The Landfill geophysical survey was designed to:

- Characterize previously identified and new contaminant migration pathways using a combination of time domain electromagnetic (TDEM) techniques and ground-penetrating radar (GPR);
- Define the subsurface extent of the Landfill with a TDEM survey technique using an EM-47 to develop a depth-dependent profile;
- Identify thaw bulbs and permafrost associated with the Landfill using an EM-34 and a GPR unit; and
- Identify buried drums and debris (if present) in the trenches northwest and south of the Landfill using an EM-31.

All geophysical investigation activities in the Landfill Source Area focused on characterizing the extent of permafrost at the Landfill and other subsurface conditions that might influence groundwater movement and, hence, the movement of potential contaminants of concern. The instruments used in the Landfill geophysical investigation were the best known available and cost-effective technologies for collecting nonintrusive data on the Landfill subsurface, given the known conditions (i.e., vegetation, refuse, and potential permafrost) of the area. Data obtained from the geophysical investigation were incorporated with available

geophysical and geological data obtained from CRREL studies and the 1994 field activities conducted at or adjacent to the Landfill Source Area to better define source area conditions.

During the 1993 field activities, a limited GPR survey was conducted at the CSY and FTPs to assist in characterization of subsurface conditions. Because of specific site conditions, these efforts did not provide data that would be useful for site characterization. Results of these surveys are discussed further in Sections 6 and 7.

2.1.1 Electromagnetic Conductivity Survey

The EM geophysical techniques employed at the Landfill measured the apparent terrain conductivity of a portion of the subsurface within the instruments' field of influence. The EM instrument transmitter coil (dipole) was energized by an alternating current that generated a primary magnetic field. This field induced a secondary magnetic field in the subsurface that was sensed by the receiver coil (dipole). The receiver coil measured the ratio of the primary and secondary magnetic fields and yielded a reading of this ratio in mmho/m. The ratio of the field strengths is proportional to the intercoil spacing and frequency of the instrument, as well as to the permeability and conductivity of the surrounding area. When intercoil spacing and frequency are fixed either as a function of the instrument design or manually (intercoil spacing only), the field ratio represents a direct indication of apparent terrain conductivity.

The apparent terrain conductivity was influenced by a number of factors including the moisture content of the subsurface, the presence and concentration of dissolved chemical species (within the thaw zone), and characteristics of the solid matrix encountered in the subsurface (e.g., permafrost, porosity, clay content, mineral composition, and compaction). Individual EM readings collected reflected the combined influence of all of these factors averaged over the effective exploration depths of the instruments, which were determined by the distance between the transmitting and receiving coils at a given frequency. The EM-31 coils are fixed, but the EM-34-3 and EM-47 have varying coil distances. Assuming that the natural characteristics of the solid matrix remain constant, the EM readings can be considered indicative of varying concentrations of sorbed soil matrix contaminant species or dissolved contaminant species in groundwater and are an excellent indication of permafrost-susceptible soils.

2.1.1.1 Instrumentation

The EM surveys were conducted using EM-31, EM-34-3, and EM-47 instruments manufactured by Geonics, Ltd. The EM-31 is effective in locating buried metal debris when operated in the in-phase mode and was used in the investigation for the buried drum and trench survey. The EM-31 and EM-34-3 also have been used effectively to identify permafrost in the subsurface at Fort Wainwright. Previous studies have shown that permafrost characteristically exhibits a conductivity of less than 1 mmho/m, while areas not underlain by permafrost exhibit a significantly higher conductivity value (E & E 1991; WCC 1988). The EM-31 was not used to delineate permafrost during the RI field activities. Comparison of past investigations indicates that the EM-31 and EM-34 provide similar results in identifying permafrost areas, although with differing degrees of scale. The EM-47 instrument operates as an EM-34 unit would in the vertical dipole mode, but with a much greater exploration depth. EM-47 readings can be used to interpret vertical stratigraphic layers.

The EM units utilized have similar characteristics; however, they have differing depths of exploration. The combination of the units provided confirmation of the presence or absence of permafrost, provided identification of metallic objects in areas where geophysical anomalies were identified, and assisted in determining lithologic variations. Sounding limitations for each instrument are listed below:

- The EM-31 has an effective exploration depth of 3 to 6 m (10 to 20 feet) depending on whether the coils are oriented perpendicular to the ground surface (vertical coplanar mode) or parallel (horizontal coplanar mode). The intercoil spacing is fixed in this instrument. The areal investigation area is small compared to the EM-34-3;
- The EM-34-3 has an effective exploration depth of 7.5 to 60 meters depending on the horizontal or vertical dipole orientation and intercoil spacing; and
- The EM-47 is a TDEM instrument and has an effective exploration depth of 75 to 100 m depending on the subsurface lithologies.

2.1.1.2 Methodology

The geophysical surveys were performed in accordance with the E & E standard operating procedure (SOP) for conducting EM conductivity surveys at hazardous waste sites and the requirements specified in the Management Plan (E & E 1993). The site-specific geophysical procedures are discussed below.

EM-31 Survey

The EM-31 instrument was positioned so that the instrument was approximately 1 m above the ground surface. The field investigation team surveyors systematically walked the survey areas (suspected drum trenches to the northwest and south of the Landfill). In-phase and quadrature instrument readings were recorded at discrete nodes where significant meter deflections were detected. The EM-31 survey was conducted using continuous profiling between locations and discrete soundings to attempt to characterize lateral and vertical variations in ground conductivity near the suspected trenches.

Because of the vegetated nature of surrounding areas at the Landfill Source Area, the EM-31 was effective only in identifying the presence of metallic debris in several of the trenches; a complete survey could not be completed. In other areas, the EM-31 was used only to provide information regarding metallic debris and disturbance in the suspected trend areas and was not used in permafrost delineation during the RI field activities. A complete discussion of survey results is provided in Section 5.

EM-34-3 Survey

EM-34-3 survey transects were established using maps, photographs, and a reconnaissance of the Landfill Source Area. Survey transects consisted of several station nodes, depending on survey transect length, in which 20- and 40-meter coil spacing readings were completed every 20 meters. The survey transect area was walked systematically, and instrument readings were recorded at the discrete nodes and at the 20- and 40-meter coil separations. The EM-34-3 instrument was positioned so that the effective exploration area of the instrument was located over the respective grid node location. Four readings were taken at each node, one each at the vertical and horizontal dipole alignment along the survey transect and again at 90° of these measurements perpendicular to the survey transect.

Before the geophysical survey, a background area transect line was established along River Road and measurements were performed at the 20- and 40-meter coil separations. The background survey area was selected so that the geology, slope, and vegetative cover were comparable to the Landfill Source Area. The background survey was conducted in an area presumed to be free of subsurface anomalies (i.e., buried metal) to ensure that the EM-34-3 unit was functioning properly.

Additionally, an interference survey was conducted near existing power lines along River Road to establish what influence the power lines had on the EM readings. The interference survey was conducted along transect lines at 20- and 40-meter coil separations parallel and perpendicular to the power lines. It was determined from the interference survey and previous investigations that the power lines have a significant influence on readings, and that the EM-34-3 instrument could not be used beneath or within 20 feet of the power lines, especially in the vertical dipole alignment.

EM survey readings were stored electronically using a data logger for later retrieval and interpretation using the computer programs DAT-34-3, EMIX 34 Plus, and SURFER. A complete discussion of the EM-34-3 survey is provided in Section 5.

EM-47 Time Domain Electromagnetic Survey

The EM-47 survey was conducted at discrete locations located along transect lines in the Landfill Source Area. Three transect lines that would provide information and correlation with other geophysical surveys and geologic cross sections were surveyed across the Landfill. The transmitter coil and receiving coil were set up at the locations, and resistivity values were recorded. A background area with comparable lithology, geology, permafrost, and vegetation to the Landfill Source Area also was surveyed using the technique described above. A complete discussion of the results is provided in Section 5.

The value of resistivity measured at the surface is a measure of all the resistivity of subsurface bodies within the area of influence of the TDEM instrument. The value measured at the surface is defined as the apparent conductivity or, inversely, the apparent resistivity of the subsurface materials at the survey location. Using a computer-driven mathematical algorithm, the apparent conductivity is transformed into true conductivity (or resistivity) and thicknesses of the individual subsurface layers encountered below the instrument.

The TDEM survey readings were stored electronically using a data logger. TDEM post-processing software was used to evaluate the decay rate of the magnetic field imposed on the subsurface materials as a function of time. The software contains an algorithm to invert the time data to depth-versus-voltage or resistivity. The differences between resistive geologic bodies is indicated by layering the resistive units with depth on a plot. Several plots, when viewed separately or along a transect line, give an indication of a geologic cross section of the underlying subsurface.

2.1.2 Ground-Penetrating Radar Survey

GPR surveys conducted by CRREL at Fort Wainwright indicated that distinctions between permafrost, nonpermafrost, and seasonal frost zones can be identified using GPR, along with structural stratification of soils and the location of the water table. When GPR data are coupled with geologic ground-truth (i.e., boring logs) GPR is an effective tool in defining the extent of subsurface features. The GPR survey at the Landfill was used to further characterize permafrost and potential contaminant transport pathways.

The GPR instrument transmits high frequency radio waves into the subsurface through a small antenna that is pulled slowly across the ground surface by a person or four-wheel drive vehicle. The GPR signal is reflected back to a receiving antenna from the interfacial surfaces between materials that exhibit different electrical properties. The variations in the return signal are amplified, filtered, processed, and recorded to produce a continuous diagrammatic cross sectional "profile" of shallow, subsurface conditions. The interfacial boundaries that generate reflections of the signal commonly are associated with natural geologic and hydrogeologic features such as bedding, cavities, fractures, intrusions, variations in type and degree of cementation, and variation in moisture and clay content. The interface between subsurface soils of differing ice content (i.e., permafrost) can produce a signal reflection.

The exploration depth of GPR instruments is highly site-specific and dependent on the specific properties of the subsurface materials. At the Landfill Source Area, the presence of electrically conductive materials such as saturated clays and silts in the shallow subsurface restricted the exploration depth of the instrument. The coal pile itself at the CSY also proved to be restrictive to explorations. However, the continuous profiles provided by the GPR survey, in conjunction with other geophysical data, offered the potential of providing more detail on the extent of subsurface features than was possible when using each of the geophysical survey techniques independently.

2.1.2.1 Instrumentation

A GPR system manufactured by GSSI of Hudson, New Hampshire, was used. The GPR system consisted of two antenna units (100 megahertz [MHz] and 500 MHz), a control unit, and graphical and digital recorders. Hand copy plots also were completed using a thermal printer while in the field for interpretation during the completion of the RI report.

2.1.2.2 Methodology

The geophysical survey was performed in accordance with the E & E SOP for conducting GPR surveys at hazardous waste sites. The site-specific procedures are discussed below.

GPR survey transects were identified using maps, photographs, and a reconnaissance of the Landfill to identify areas in which the GPR unit could be towed either by hand or vehicle. Once a survey line was identified, the antenna was placed on the end of the survey line and was connected to the central unit and graphic recorders using the appropriate cables. The GPR instrument then was pulled over the survey transect area of interest, while the electronic signal of the instrument was recorded graphically and/or digitally. The GPR survey was conducted over several available roads and trails in the Landfill Source Area in a manner that placed the GPR adjacent to as many borehole, monitoring well, and other geophysical survey locations as possible, to provide ground-truth data for data interpretation. GPR transects were designed to intersect "point" locations of soil borings and monitoring wells.

Before performing the GPR survey, background areas were selected near the CSY and the Landfill with comparable geology, slope, vegetation cover, and permafrost, to determine whether the unit was functioning properly and to compare with CRREL data previously obtained for the source areas. The background transect at the CSY served as the background for the FTPs.

The GPR transects were recorded graphically on strip chart paper for real-time analysis in the field and later interpretations. The GPR transects also were stored electronically for potential digital processing in the future to enhance subsurface features using modeling software. Results are discussed in detail in Section 5.

2.2 FIELD LABORATORY SCREENING

Field screening of 296 soil, subsurface soil, and sediment samples and 153 ground-water and surface water samples was performed at the OU-4 field laboratory. All samples were screened for TRPH and/or volatile organic compounds (VOCs). The field screening results provided tentative identification and estimated concentrations of the target analytes. A complete summary of the field laboratory samples is provided in Volume 3, Field Laboratory Analytical Results.

2.3 GEOPROBE™ GROUNDWATER INVESTIGATION

A van-mounted hydraulic percussion system (Geoprobe™ Model 8M) was used to drive collection rods and screens into the subsurface aquifer zone beneath the CSY and FTPs to collect various types of data (i.e., water levels, groundwater samples, and volatiles in headspace (Table 2-1)). Locations at the Landfill were selected to determine the depth to groundwater before the installation of monitoring wells but not to collect samples. Three Geoprobe™ installations were completed at the Landfill. Fifty-eight Geoprobe™ locations were selected at the CSY to characterize groundwater conditions throughout the source area and surrounding areas that might be impacted. After analytical results were obtained from initial locations, further Geoprobe™ locations were completed to delineate groundwater contamination. At two selected locations adjacent to defined groundwater contamination at the CSY, the Geoprobe™ rods were driven to the maximum depth possible (36 and 45 feet, respectively) to collect discrete groundwater samples at depth. Thirty-five locations were completed at the FTPs over a broad area with a majority of the locations selected within the training pit cleared areas.

Following the completion of each Geoprobe™ installation, groundwater samples were screened in the field laboratory. Field screening petroleum hydrocarbon (FSPH) analysis (FSPH Method 418.1) using a Horiba photoanalyzer and field screening volatile organic compound (FSVOC) analysis using a purge and trap extraction and gas chromatograph equipped with photoionization and electron capture detectors were used for initial groundwater screening. The field screening of groundwater samples provided real-time data for determination of areal extent of contamination.

2.3.1 Methodology

The Geoprobe[™] groundwater sampling followed E & E's SOP for conducting Geoprobe[™] operations at hazardous waste sites. Groundwater sampling stations were selected in the field by E & E representatives using the results from previously established boring and monitoring well locations and background information on potential contamination sources. After utility clearances were obtained at each location, Geoprobe[™] rods were driven at least 2 feet below the water table to enable sample collection. Floating product was anticipated at the FTPs Source Area, so Geoprobe[™] rods were driven to just above the water table, checked for product with a flame ionization detector (FID), then driven through the water table

interface. A standard electric water-level meter was lowered into the probe rods to confirm positioning before initiation of groundwater sample collection.

In general, groundwater sampling followed the well point sampling guidelines outlined in the SOP on Geoprobe™ operations. Stations constructed for Geoprobe™ groundwater sampling purposes were sampled in the following fashion:

- Following probe installation, static water level readings were collected using a water level meter to confirm appropriate rod positioning;
- Disposable polyethylene tubing was lowered through the probe rod below the water table to the screened interval or exposed sample interval. The tubing then was connected to silicon tubing, which was used in the peristaltic pump to draw the groundwater sample to the surface. No floating product nonaqueous phase liquid (NAPL) was encountered at the CSY, FTPs, or Landfill;
- At least one equivalent standing water well volume was purged before sampling of the groundwater, if appropriate. Only one well volume was purged since the sampling tubing occasionally becomes clogged with sand and silt if too many water volumes are withdrawn. Two 40-milliliter (mL) volatile organic analysis (VOA) vials were filled with the groundwater sample for analysis in the field laboratory; and
- Samples were analyzed for FSPH and FSVOC.

At the completion of sampling, each GeoprobeTM station was abandoned by pouring solid granular bentonite through a funnel down the open hole to the water table following removal of the rod string. Abandonment was completed by tapping additional bentonite into the hole at the surface and covering the site with original soil.

In several holes completed at the FTPs, probe rods were broken off because of the presence of near-surface rocks and/or debris. In these instances, attempts were made to remove the downhole probe rods. Removal of some of the probe rods was successful, although in several instances, the probe rods could not be recovered. When probe rods could not be recovered, the holes were abandoned with bentonite chips, as described above, and a nearby location was chosen for continuation of the groundwater investigation.

2.4 MICROWELL SAMPLING

During the groundwater contamination investigation at the CSY, the Corps used an alternate groundwater sampling technique through a cooperative agreement with another contractor. The technique, referred to as MicroWell sampling, is similar to GeoprobeTM sampling. Carbon steel tubing was welded together and driven to groundwater to collect groundwater samples. Because the tubing used was much thinner than the stainless steel GeoprobeTM rod, hammer forces were transmitted along the tubing with little dampening effect. As a result, the tubing can be driven to greater depths. The maximum depth obtained was approximately 120 feet BGS. Sample tubing then was inserted into the steel tubing to sample the groundwater. Groundwater samples were obtained using a check valve system that, when moved up and down, lifted the groundwater to the surface where a sample then was collected.

MicroWell locations at the CSY were selected by E & E and Corps field personnel to provide discrete groundwater sample data at various depths in the saturated zone to the maximum depth attainable with the tubing. Locations were mainly adjacent to the coal pile, with two locations on the coal pile. Ten MicroWell locations were completed. All MicroWell samples in the field and project laboratories were analyzed for VOCs. Table 2-2 provides a MicroWell sample summary.

The driving force for the MicroWells was a vibratory hammer drill. As such, the carbon steel tubing could not always be removed from sample locations and abandonment of the location could not be performed as described for the Geoprobe™ sampling locations. In most cases, the tubing was cut off flush with the ground surface; however, at the two locations on the coal pile, the tubing was removed using other equipment. The tubing and holes were not filled with bentonite or grout but were covered with native soil.

2.5 SURFACE SOIL INVESTIGATIONS

The surface soil sampling program was designed to define the nature and extent of surface soil contamination and to collect sufficient data to evaluate remedial action alternatives. Surface soils were collected in areas of known and suspected contamination, from areas of visibly stained soil or stressed vegetation.

2.5.1 Methodology

Surface soil samples were collected as grab samples from the top 0 to 6 inches of soil using a dedicated or decontaminated stainless steel spoon to collect each sample. A shovel first was used to dig through the coal to the native soil at the CSY. A portion of the sample was placed directly into two 2-ounce vials with Teflon-lined septa for VOC analysis. The remaining material was homogenized in a disposable aluminum pan. Large pieces of gravel, wood, organic matter, and/or coal were removed before placing the soil into sample containers.

All surface soils were screened at the on-site field laboratory for TRPH and certain VOCs, as described in Section 4. Analyses performed by the project laboratory are presented in Table 2-3. As indicated in the table, two or three surface soil samples from each source area also were analyzed for Atterberg limits, moisture content, grain size, nitrate/nitrite, and phosphorus. Approximately 5% of the samples were analyzed for DRO and gasoline-range organics (GRO) to assess the comparability of these methods to the fuel ID method. Most samples were analyzed by modified Method 8015, the fuel ID method.

2.5.2 Surface Soil Sample Locations

2.5.2.1 Landfill Source Area

Landfill surface soil samples were collected to determine if contaminants have migrated from the Landfill to the surrounding surface soils by wind or surface water erosion. Sampling locations included two background locations, the former trenches, the drainage swale in the southwest corner of the Landfill, and the drainage swale south of River Road, extending southeast of the Landfill to the Chena River. Additional surface soil samples were collected based on field observations, such as stained soil and results of field screening analyses. Additionally, eight ash samples were collected as surface samples from the cover of the active Landfill. All surface soil sample locations are illustrated on Figure 2-1 (located at the back of this volume).

2.5.2.2 Coal Storage Yard Source Area

Although the main target of investigation in the CSY Source Area was subsurface contamination, six surface soil samples, including one background sample, were collected

from soil boring and monitoring well locations (see Figure 2-2 located at the back of this volume).

2.5.2.3 Fire Training Pits Source Area

Surface soil samples were collected from 54 locations at the FTPs Source Area (see Figure 2-3 located at the back of this volume). Surface soil sample grids were established to characterize the large oil stain, the small oil stains, and the former drum storage area at the FTP-3A area. Surface soils were collected at borings and monitoring well locations at FTP-3B, and at upgradient and downgradient locations. An area north of the access road was sampled to delineate surface contamination identified by FSPH analysis.

2.6 SURFACE WATER AND SEDIMENT INVESTIGATIONS

Surface water and sediment samples were collected from the representative surface water bodies at the source areas to determine whether contaminants have migrated to surface waters and sediments and to determine possible surface water and groundwater contaminant migration pathways. In general, sediment samples were collocated with surface water samples; however, in many instances, no water was present and only sediment samples were collected.

2.6.1 Methodology

Surface water and sediment samples were collected moving from downstream to upstream locations so that subsequent sample locations would not be disturbed by water column turbidity caused by sampling upstream. For collocated surface water and sediment samples, the surface water sample was collected first. Surface water samples were collected by gently submerging sample containers under water to fill the container. Agitation of the water was minimized to prevent loss of VOCs and increases in the dissolved oxygen (DO) content of the samples. Physical characteristics of the surface water, such as color, odor, sheen, and turbidity, were noted at the time of collection. The samples were chemically preserved (if appropriate) and sealed immediately after collection.

Both filtered and unfiltered samples were collected at each sample location. Samples submitted for dissolved metals analysis were filtered using a vacuum hand-pump or a

peristaltic pump. The dedicated filter equipment utilized 100 micron disposable filters. A summary of surface water samples and analyses performed is presented in Table 2-4.

Sediment samples were collected as grab samples from 6 inches below the sediment surface, using dedicated stainless steel spoons, except for four locations at the Landfill Source Area. At these locations, sediments were collected with a hand auger from 0 to 6 inches BGS, 2.5 feet BGS, and 5 feet BGS, yielding three samples per location. For all samples, a portion first was placed into two 2-ounce jars for VOC analysis. The remaining material then was homogenized in disposable aluminum pans and placed in the remaining sample containers.

Analyses performed on sediment samples are presented in Table 2-4. In addition, the six sediment samples collected from the Chena River were analyzed for sediment toxicity. These samples were collected, stored, and tested in accordance with the following American Society for Testing and Materials (ASTM) standards:

- ASTM E 1391-90, Standard Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing;
 and
- ASTM E 1383-90, Standard Guide for Conducting Sediment Toxicity Test with Freshwater Invertebrates.

Sediment samples were divided into subsamples for total organic carbon (TOC), particle size, and total ammonia. Sediment characteristics, such as texture, color, and organisms, were noted in the field. Exposure to air was limited during collection, and the containers were completely filled, leaving no headspace, and sealed air-tight.

2.6.2 Surface Water and Sediment Sample Locations

2.6.2.1 Landfill Source Area

Twenty-four sediment and 16 surface water samples were collected at the Landfill Source Area. At four locations within wetlands at the north side of the Landfill, sediment borings were augured to 5 feet using a hand auger. Samples were collected at the surface, 2.5 and 5 feet BGS, for a total of 12 samples. Four surface water samples also were collected at these locations. Collocated surface water and sediment samples were collected from two additional wetland areas to the east of the Landfill Source Area; from ponded water in two locations near the Former Trench Area; and from six locations in the Chena River,

three upgradient and three downgradient of the Landfill. Two background surface water and sediment sample locations were sampled on the northwest side of the Landfill. Sediment samples were collected from the drainage swales southeast and southwest of the Landfill; surface water was not present, and therefore, no surface water samples were collected. These samples then were designated as surface soil samples.

2.6.2.2 Coal Storage Yard Source Area

Ten sediment and two surface water samples were collected from the CSY Source Area. Four samples were collected from locations along apparent drainages (see Figure 2-2), and five were collected from the cooling ponds, including one duplicate sample. Two surface water samples were collocated with two of the cooling pond sediment samples, one sample near the outflow (discharge from the power plant) and one sample near the intake (intake pumped to the power plant) to the cooling pond. The field investigation team originally planned to utilize a floating craft and an Eckman dredge to collect samples from the center of the cooling pond. However, prolific vegetation was encountered and rendered this sampling method unfeasible. Samples subsequently were obtained using a hand auger with an extension to collect the samples approximately 5 feet in from the edges of the cooling ponds.

2.6.2.3 Fire Training Pits Source Area

Surface water was not present at the FTPs during the sample collection period. Fifteen sediment samples were collected from drainage ways, depressions, and an apparent wetland area near the FTPs (see Figure 2-3).

2.7 SUBSURFACE SOIL INVESTIGATIONS

The subsurface soil investigation was designed to characterize the nature and extent of potential subsurface contamination and contaminant migration pathways. Subsurface soil samples were collected at soil boring and monitoring well locations defined for each source area.

2.7.1 Methodology

Subsurface soil samples were collected from soil borings and during monitoring well installation. Two drilling methods were used: a track-mounted (Nodwell) hollow-stem auger

rig using 8-inch outside diameter (OD; 10-inch OD for 4-inch monitoring wells) auger flights was used for the shallower boreholes and piezometer nests, and a Schram T64D/H air rotary rig was used for soil borings and monitoring wells at depths greater than 100 feet BGS. Subsurface soil samples were collected at approximately 5-foot intervals from each boring. Additional samples were collected at changes in lithology or when groundwater or permafrost was encountered. Air rotary drilling was chosen mainly because of the expected total depth of monitoring wells (200 feet BGS), the speed of drilling as compared to other techniques (cable-tool), and previous use at other sites (historic use). Because air pressures are used to remove drill cuttings from the borehole, this method potentially may reduce the contaminant concentration levels that may exist within the soils. Samples collected with the split-tube sampler were removed immediately for volatile analysis to minimize further volatilization, as prescribed by the MP.

Samples were collected using a 24-inch-long, 3-inch OD, split-tube sampler. The split-tube sampler was driven by a 300-pound weight dropped through an approximate 24-inch-height interval. The procedures followed for split-tube sampling are described in ASTM D1586 (ASTM 1991). The split-tube sample lithology was described by a geologist in accordance with ASTM D2488, ASTM 4083, MIL-STD-610B, and using descriptive techniques discussed in Folk (1966).

Organic vapor measurements and a description of lithology from each split-tube sample were recorded. If off-site laboratory analyses were planned for the sample, sample material was removed from the split tube with a stainless steel spoon and placed directly into appropriate prelabeled sample containers.

Because of low sample recovery and the sample volume requirements (QA/quality control [QC] triplicate samples), two to three split tubes typically were driven to collect sufficient volume. Occasionally, a larger OD sampler was used.

A sample aliquot from every sample location was sent to the field laboratory to determine whether TPH or VOC contamination was present. A maximum of two samples per soil boring (one at the groundwater interface and one selected based on field screening results) was submitted to the off-site project laboratory. Table 2-3 presents a summary of all soil samples collected for the fixed laboratory and analyses performed. Approximately 5% of the samples were analyzed for DRO and GRO to assess the comparability of these methods to

the fuel ID method. All project laboratory samples were analyzed by Corps modified 8015 for fuel ID.

All boreholes drilled during the RI were abandoned by filling the hole to the surface with Pure Gold grout that consisted of a uniform fluid admixture of bentonite and water. The grout contained at least 30% solids by weight and had a density of 9.4 pounds per gallon (ppg) or greater. Markers were placed at the surface to aid the surveying of borehole locations.

2.7.2 Subsurface Sample Locations

2.7.2.1 Landfill Source Area

Subsurface soil contamination was documented at the Landfill. For this investigation, soil borings were drilled to delineate the extent of contamination and to define background conditions. Monitoring wells were installed at wells AP-6130 through AP-6140, and soil borings were drilled at locations AP-6176 through AP-6180. Soil boring SB-5 was not surveyed (see Figure 2-1). Thirty-seven subsurface soil samples were collected for field screening analysis; 18 subsurface soil samples were submitted for fixed laboratory analyses.

At drilling locations AP-6179 and AP-6180, air rotary operations encountered unconsolidated saturated sands at approximately 20 feet BGS. Continued drilling caused sand in the surrounding formation to collapse into the borehole and discharge with the drill cuttings. This condition caused the ground surface adjacent to the borehole to collapse and compromised the stable footing of the drill rig. Monitoring well locations AP-6179 and AP-6180 were, therefore, abandoned with bentonite after reaching total depths of 120 and 130 feet BGS, respectively. No monitoring wells were constructed within the boreholes.

2.7.2.2 Coal Storage Yard Source Area

Previous investigations at the CSY indicated the presence of benzene, trichloroethene (TCE), TRPH, DROs, and toluene in subsurface soils. For this investigation, 10 soil borings were completed at the CSY, including two that were drilled through the active coal pile. Field screening results were used to determine the optimum placement of the soil borings and to delineate a plume of contamination in subsurface soils beneath the coal pile. Four of the borings were completed as monitoring wells, specifically AP-6141, AP-6142, AP-6143, and

AP-6144 (see Figure 2-2). Soil boring locations included AP-6158 through AP-6168. The AP-5000 series of monitoring wells, also depicted in Figure 2-2, was installed during previous investigations.

2.7.2.3 Fire Training Pits Source Area

Previous investigations indicated the presence of BTEX compounds, DROs, and 2-methylnapthalene at depth at the FTPs. Thirteen monitoring wells and seven soil borings were drilled as part of this investigation. Field screening sample results were used to determine the optimum placement of soil borings and monitoring wells. One or two samples from each borehole and monitoring well location were submitted to the fixed laboratory for analyses. Monitoring wells were installed at locations AP-6145 through AP-6157. Soil borings were drilled at locations AP-6169 through AP-6175 (see Figure 2-3).

2.8 GROUNDWATER INVESTIGATION

To identify the nature and extent of groundwater contamination, specific source area conditions, background baseline information, and an understanding of groundwater movement beneath potential contamination sources were necessary. Review of the CSM, the OU-4 MP, and other sources of regional information indicated that the current system of groundwater monitoring wells installed at OU-4 was incomplete and, therefore, unable to provide this information. The existing monitoring well system provided an effective regional characterization of the fort but little detail with respect to the OU-4 site-specific locations. As part of the characterization of the extent of contamination, evaluation of potential migratory pathways, characterization of geologic and hydraulic parameters, and appropriate remedial action alternatives, the field activities included installation of monitoring wells and piezometer nests capable of providing the necessary information. The strategies for each monitoring well installation are listed below:

Well	Data Use
LANDFILL	
AP-6130 AP-6131 AP-6132 AP-6133 AP-6134 AP-6135 AP-6136 AP-6137 AP-6138 AP-6139 AP-6140	Upgradient and background groundwater quality—Deep Upgradient and background groundwater quality—Chena River influence Upgradient and background groundwater quality—Chena River influence Upgradient and background groundwater quality—Chena River influence Southwest transport pathway groundwater—Deep Southwest transport pathway groundwater—Deep Southwest transport pathway groundwater—Deep Southwest transport pathway groundwater—Shallow Southwest transport pathway groundwater—Deep Southeast transport pathway groundwater—Shallow Southeast transport pathway groundwater—Shallow
Well	Data Use
CSY-1993	
AP-6141 AP-6142 AP-6143 AP-6144	Upgradient and background conditions Deep groundwater nest; vertical gradients Shallow groundwater nest; vertical gradients Downgradient conditions near coal pile
CSY-1994	
AP-6518 AP-6519 AP-6520 AP-6521 AP-6522 AP-6523 AP-6524	Shallow groundwater downgradient of coal pile Intermediate groundwater downgradient of coal pile Deep groundwater downgradient of coal pile Shallow groundwater downgradient of coal pile Deep groundwater downgradient of coal pile Shallow groundwater downgradient of coal pile Intermediate groundwater downgradient of coal pile
FTP	
AP-6145 AP-6146 AP-6147 AP-6148 AP-6149 AP-6150 AP-6151 AP-6152 AP-6153 AP-6154	Groundwater quality of FTP-3A Background groundwater quality for FTP-3B Background groundwater quality for FTP-3B Groundwater quality of FTP-3B Groundwater quality of FTP-3B Groundwater quality downgradient of FTP-3B Groundwater quality downgradient of FTP-3B Groundwater quality downgradient of FTP-3B Groundwater quality of FTP-3A Groundwater quality of FTP-3A
AP-6155 AP-6156 AP-6157	Shallow groundwater nest; vertical gradients Deep groundwater nest; vertical gradients Background groundwater quality for FTP-3B

Piezometer nests were installed at each source area and given the same designation as monitoring wells to determine local vertical components of groundwater flow, and to provide additional data about the regional groundwater flow pattern. Previously completed Corps wells were used in the piezometer nests, when appropriate. Two-well nests for the CSY and Landfill, and a three-well nest for the FTPs, were completed. Each piezometer nest included a water table monitoring well with a screened interval spanning the expected range of groundwater fluctuations, and either one or two piezometers with relatively short screen intervals (i.e., 2 feet) completed at depths below the water table.

Thirty-eight new monitoring wells and/or piezometers were constructed and installed at OU-4 during the 1993 field season, and seven additional wells were installed at the CSY during 1994. Table 2-5 lists the wells sampled at each source area and analyses performed. Construction of wells and piezometers is described in Section 2.7.1. As-built diagrams of the monitoring wells and piezometers are presented in each source area investigation section. The boring logs for all drilling locations are included in Appendix B.

During construction of wells at the Landfill, permafrost was encountered near the ground surface and continued to depths of 24.5 and 25 feet BGS, respectively, at AP-6130 and AP-6140. At these depths, permafrost abruptly ended and saturated sands and gravels were encountered. Well screens were installed within the saturated zone. Both wells failed to produce adequate quantities of water; therefore, no samples were collected. Well AP-6131 was completed to a total depth of 98 feet BGS and was developed. Recovery was slow and did not reach equilibrium by the time of groundwater sampling. The well was purged dry and again recovered slowly; therefore, it was not sampled. It is suspected that these wells were completed in talik zones.

2.8.1 Monitoring Well Installation and Construction

Shallow wells and piezometers typically were constructed of 2-inch inside diameter (ID), Schedule 80 National Sanitation Foundation- (NSF-) approved polyvinyl chloride (PVC) casing with flush-threaded joints. Four-inch Schedule 80 casing was used if the well was more than 50 feet deep, if permafrost conditions existed, or if potential remedial wells might be required. The wells were screened using 2-inch or 4-inch Johnson Environmental Vee-Wire stainless steel 0.008-inch slot size continuous wound, 40-60 prepack environmental screens. A 1- to 3-foot-long, 2- or 4-inch-diameter, Schedule 40 or 80, matching thread,

NSF-approved sump was attached to the base of the well screen. All polyvinyl chloride (PVC) joints were of matching flush-threaded design with viton o-rings and were screwed together without the use of glues, epoxies, or petroleum-based lubricants. All materials were precleaned and placed in polyethylene bags at the factory; the bags remained sealed until the time of installation. The annular space of each soil boring had a minimum radius of 2 inches from the soil to the well casing.

Because of extreme formation sloughing, bentonite was used to complete two wells at the Landfill (i.e., AP-6136 and AP-6138). Both wells were designed to be deep wells, with completion at approximately 100 feet BGS. Well AP-6138 was initiated with the air rotary drill rig; however, sand sloughed into the driven casing and prevented installation of the well casing and screen. After several air rotary rig attempts, well installation was attempted using the hollow-stem auger. Two attempts were made with the auger flights continuously filled with water during the drilling process to help prevent sand from entering. These attempts failed. Two additional attempts were made, where after reaching total depth (i.e., 100 feet BGS), a wooden plug installed at the bottom of the auger to prevent sand from surging into the auger flights was knocked out with a steel rod. Subsequently, the well assembly was lowered into the auger flights but sand still surged and prevented the screen assembly from reaching total depth. An attempt was made to knock the wooden plug out using the well assembly, thereby saving time to remove rods and lower the well assembly, but the assembly did not provide sufficient weight to force the plug out. Finally, a bentonite slurry was used successfully to slow the influx of sand into the bottom of the auger. Well AP-6136, located within the same drainage area southwest of the Landfill, was completed to 100 feet BGS using the bentonite slurry technique.

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As-built drawings for all completed wells and piezometers at each source area are included in Appendix B.

2.8.2 Monitoring Well Sampling

Sampling of groundwater in monitoring wells and/or water supply wells consisted of the following activities:

• Evaluating existing monitoring well construction and the integrity of the well, if appropriate;

- Measuring depth to water level and total well depth (to calculate purge volume). For a domestic or water supply well, the water level and total well depth were estimated;
- Evacuating water (purging);
- Measuring and recording groundwater temperature, pH, conductivity,
 DO, turbidity, and reduction/oxidation potential (Eh); and
- Collecting groundwater samples.

A minimum of three volumes of the standing water column was purged from each well before sample collection to ensure that the sample was representative of the groundwater. Purge water was drummed and treated (see Section 2.9). Purging was performed using a decontaminated submersible pump. A disposable Teflon bailer then was used to collect the groundwater sample. Domestic or water supply wells were sampled at the spigot nearest to the well pump. The spigot was opened, and water was allowed to run for a minimum of 10 minutes. Monitoring well groundwater sampling final parameters are presented in Table 2-6.

2.8.3 Groundwater Elevation Measurements

An effort was made to record groundwater elevation measurements daily during the field investigation for the RI. Existing monitoring wells and new monitoring wells, as they were installed, were measured at each source area. Daily measurements provided data on local and regional groundwater trends and potential fluctuations in flow direction and/or gradient over time.

Static groundwater elevations were measured to the nearest 0.01 foot with an electronic probe. No floating product was encountered in any of the wells monitored at the OU-4 source areas. Long-term monitoring of wells (beyond the actual length of field activities) was not conducted for OU-4. However, CRREL has established an array of transducers in selected wells (i.e., 3595-01, 3595-02, and 3595-03) completed in the drum storage area of the CSY, and the United States Geological Survey (USGS) constantly monitors a well on Fort Wainwright, as well as the Chena River and Tanana River stages.

Specific source area groundwater elevation measurements and groundwater flow direction and gradients are discussed in the source area investigation sections. Appendix C contains individual groundwater elevations for each well monitored.

2.8.4 Aquifer Testing

Because of the large volumes of water needed to conduct appropriate hydrologic tests at each area, pump tests were not conducted. Instead, slug tests were performed to estimate pertinent hydraulic parameters of the underlying aquifers. Slug tests were performed at wells AP-6140, at the Landfill; AP-6156, at the FTPs; and AP-6143, at the CSY.

A slug test commonly consists of instantaneously injecting or withdrawing a known volume of water from a well and measuring the fluctuation of the groundwater elevation with respect to time as it returns to its static condition. A data logger and pressure transducer or equivalent method is used to determine head changes.

A pneumatic slug test method, as outlined by McLane *et al.* (1991), was employed to raise and depress the groundwater table at least 10 feet at the OU-4 wells within the riser casing by creating a vacuum and pressure, respectively, without generation or introduction of water into the well. A Gast compressor/vacuum pump was used to provide the positive and negative pressures needed to lower and raise the groundwater table. An In-Situ, Inc., Hermit 2000 data logger and In-Situ, Inc., 10 pounds per square inch (psi) and 20 psi pressure transducers were used to measure the respective changes in groundwater elevation. The data were stored in the data logger memory and then downloaded into a portable computer and backed up on disk.

The data collected from the slug tests were analyzed using standard test methods for aquifer testing found in a number of references (Freeze and Cherry 1979, Domenico and Schwartz 1990, Kruseman and de Ridder 1990, Dawson and Istok 1991, Driscoll 1986). Two methods were chosen to estimate hydraulic parameters: the Cooper *et al.* (1967) method, which is used mainly for a fully penetrating well in a confined aquifer, and a modified version of the Hvorslev (1951) method outlined by McLane *et al.* (1991), which can be used in either unconfined or confined aquifers and can account for different well completions.

The computer program Graphical Well Analysis Program (GWAP; Groundwater Graphics 1987) was used to perform the Cooper *et al.* method (1967), while a Lotus 123 spreadsheet was used to manipulate the data for analysis using the Hvorslev method (1951).

Previous aquifer testing has been performed at Fort Wainwright, particularly at the Landfill (WCC 1989; United States Army Corps of Engineers [USACE] 1986, 1991b, and 1992d). In addition, the OU-3 RI produced aquifer hydraulic values in agreement with those found during the OU-4 investigation. Specific source area hydraulic measurements are

discussed in the source area investigation sections. Additionally, work performed by USGS and CRREL using flow probes installed in monitoring wells across the fort has provided additional information on groundwater flow directions at OU-4 source areas (CRREL 1995). Their work is continuing and additional data may be available after the completion of this document.

The slug testing performed at the OU-4 source areas was intended only to check hydraulic values determined from previous investigations, as approved in the MP. It is widely accepted that the alluvial aquifer is very conductive and transmissive in nature, and that discontinuous permafrost, silt units, bedrock, and well construction affect local groundwater movement. Slug testing results provided a range of values to compare to other source area investigations, ongoing research work, and proposed testing activities.

2.8.5 Hydrogeochemistry

Chemical analyses of groundwater and surface water samples included cation and anion analyses to characterize the chemistry of the underlying aquifers and surface water bodies, and provide insight into potential surface water-groundwater interactions and contaminant fate and transport. The computer programs STIFF (Beljin 1985) and WATEVAL (Hounslow and Goff 1988) were used to provide general initial chemical analyses of groundwater at OU-4 source areas. The STIFF program generates Stiff diagrams (Stiff 1953), in which the general geometric shape of cation and anion plots provide a fingerprint that can be used to qualitatively compare different groundwater samples. WATEVAL provides a general mass balance of groundwater samples that can be used to evaluate groundwater origin and potential chemical processes and produces Piper diagrams (Piper 1944), in which, like the Stiff program, diagrams can be used to evaluate different groundwater samples. The program also provides an indication of source rock determination based on a simplistic mass balance approach as discussed in Garrels and Mackenzie (1967). Water mass balance calculations are provided in Appendix H.

2.9 WELL DEVELOPMENT, COMPLETION, AND PROTECTION

Wells were developed by surging and overpumping using a 2-inch submersible Grundfos pump, and/or by bailing with a Teflon bailer, to achieve maximum hydraulic connection. Well development continued until a minimum of three to five well volumes had

been purged, the water was free of sediment, and the following parameters had stabilized within the ranges specified:

pH +/- 1 pH unit
Temperature +/- 0.5° C
Conductivity +/- 10%Oxidation/Reduction +/- 10%Dissolved Oxygen +/- 10%

Turbidity measurements also were recorded. Well development records are included in Appendix C. Field parameter final sampling measurements are included in Table 2-5.

In accordance with USACE guidelines, a 1-L sample of water was collected in a clear, glass jar at the completion of development of each well. These samples were labeled and photographed using 35 millimeter (mm) color slide film. The photograph provided a back-lit closeup view that shows the clarity of the water. All slides are presented in Appendix D (some RIR copies include color prints instead of slides).

A 5-foot steel surface protective casing was fitted over the well casings and grouted into place. A minimum of 3 feet of casing was set into the ground. A crushed gravel pad, 3-foot square minimum, sloping away from the well, was constructed around the well casings at the final ground level. Three steel posts were spaced evenly around the well and embedded in the gravel pad to serve as guards. The steel protective casing was painted with permanent high-visibility paint. A fiberglass pole was attached to the well casing to identify its location during periods of heavy snowfall.

All monitoring wells were equipped with a locking aluminum custody seal to prevent tampering, in addition to the standard Corps padlock. The custody seals were labeled with an alphanumeric code number that will be changed during each sampling event. The code number included the monitoring well number and the date of the last sampling event (i.e., AP-5588-93-09-28). Table 2-7 summarizes the custody seal numbers for 1993. The wells sampled in 1994 were not resealed, at the direction of the Corps. Before breakage of the custody seal for each sampling event, the integrity of the seal and code number (when readable) were noted in a field logbook. Most of the custody seals were rust-coated from the surrounding steel, and the code numbers were illegible.

2.9.1 Well and Monument Location Survey

Horizontal coordinates and elevations for each monitoring well were established by the Corps. Horizontal coordinates also were established for each soil boring not completed as a monitoring well. Coordinates were measured to the closest 1 foot and referenced to the State Plane Coordinate System, and to the fortwide grid system. Elevations were measured to the closest 0.01 foot at a reference point on the north lip of the inner well casing (uncapped), based on the National Geodetic Vertical Datum. The location, identification, coordinates, and elevations of the wells were plotted on the existing topographic base map prepared for OU-4. Table 2-8 presents the locations of all monitoring wells installed during the OU-4 RI. Coordinate information for soil borings is provided in the boring logs (see Appendix B).

2.10 HANDLING OF INVESTIGATION-DERIVED WASTE

2.10.1 Investigation-Derived Waste Water

As part of the OU-3 RI/FS, E & E operated a water treatment system in Building 3489 for purge water, development water, and decontamination water generated during investigation activities. This system also was used to treat OU-4 investigation-derived waste.

For the OU-3 and OU-4 investigations, more than 200 drums (11,000 gallons) of investigation-derived waste water were treated at a rate of approximately 200 gallons per day (gpd). The treatment system consisted mainly of:

- A Calgon Carbon Flowsorb unit;
- Two 220-gallon minibulk water storage tanks;
- A one-half horsepower stainless steel booster pump with a float switch control; and
- A 20-micron prefilter with a 10-micron filter.

The treated water was discharged directly into the Fort Wainwright sewer system under a discharge permit issued by Fairbanks Municipal Utilities Systems-Water/Wastewater (MUS).

2.10.2 Investigation-Derived Waste Soil

All drill cuttings were screened using a FID. If organic vapors from the drilling exceeded 50 ppm using the FID, they were drummed. Four drums of soil were staged at the

bioremediation cells south of the Landfill. Drill cuttings with organic vapors less than 50 ppm on the FID were not drummed and were piled where they were generated.

2.11 ECOLOGICAL INVESTIGATION

Activities performed as part of the ecological investigation involved collection and review of information for the screening-level ecological risk assessment. Interviews with the Fort Wainwright biologist were conducted, and available information was collected and reviewed, including:

- Descriptive physical and ecological data to characterize habitats and receptors at the site, such as vegetation, wetlands descriptions and maps; wildlife species inventories; ecological surveys and studies; soil surveys; climatological data; topographical maps; and aerial photographs;
- Measured or estimated concentrations of contaminants of potential concern (COPCs) at ecologically relevant locations. Ecologically relevant locations refer to areas that are suitable or potentially suitable to support indicator species;
- An evaluation of wetlands in the potentially affected area to determine their functional values (i.e., their values as a wildlife habitat) for pollution abatement, and for flood control using the United States Fish and Wildlife Service (USFWS) wetland maps;
- Information on physical properties of sediment (e.g., particle size and TOC) and surface water (e.g., hardness, DO, pH, and conductivity);
- Information on the presence of endangered, threatened, or rare species (federal and state); and
- Information on the location of wildlife sanctuaries, fisheries, or other protected/regulated habitats in the vicinity of the site, provided by federal, state, and local agencies.

A field reconnaissance was not conducted by E & E at OU-4. An inventory of wildlife and vegetation for OU-4 was provided by a DPW biologist. However, sediment toxicity samples were collected and analyzed to assess the ecological impacts to freshwater invertebrates in the Chena River.

Location	Sample Depth (feet)	Project Laboratory Sample
Coal Stora	ge Yard	
CSY-01	18	No sample obtained
CSY-02	15	CSY001
CSY-03	9	CSY002
CSY-04	6	CSY003
CSY-05	18	No sample obtained
CSY-06	15	CSY004
CSY-07	24	CSY005
CSY-08	18	CSY006
CSY-09	27	CSY007
CSY-10	21	CSY008
CSY-11	21	CSY009
CSY-12	21	CSY010
CSY-13	21	CSY011
CSY-14	21	CSY012
CSY-15	21	CSY013
CSY-16	24	CSY014
CSY-17	24	CSY015
CSY-18	15	CSY016
CSY-19	15	CSY017
CSY-20	21	CSY018
CSY-21	21	CSY019
CSY-22	15	CSY020
CSY-23	27	CSY023
CSY-24	18	CSY024
CSY-25	18	CSY025
CSY-26	18	CSY026
CSY-27	27	CSY027
CSY-28	27	CSY028
CSY-29	24	CSY029

Key at end of table.

Location	Sample Depth (feet)	Project Laboratory Sample	
CSY-30	30	CSY030	
CSY-31	18	CSY031	
CSY-32	21	CSY032	
CSY-33	- 21	CSY033	
CSY-34	21	CSY034 (blind duplicate of CSY033)	
CSY-35	27	CSY035	
CSY-36	27	CSY036	
CSY-37	27	CSY037	
CSY-38	27	CSY038	
CSY-39	21	CSY039	
CSY-40	18	CSY040	
CSY-41	21	CSY041	
CSY-42	24	CSY042	
CSY-43	24	CSY043 (CSY-43 24 feet BGS)	
CSY-44	36	CSY044 (CSY-43 36 feet BGS)	
CSY-45	45	CSY045 (CSY-43 45 feet BGS)	
CSY-46	45	CSY046 (blind duplicate of CSY045)	
CSY-47	45	CSY047 (blind duplicate of CSY045)	
CSY-48	24	CSY048	
CSY-49	24	CSY049 (blind duplicate of CSY048)	
CSY-50	24	CSY050	
CSY-51	24	CSY051	
CSY-52	21	CSY052	
CSY-53	21	CSY053	
CSY-54	24	CSY054	
CSY-55	24	CSY055 (blind duplicate of CSY054)	
CSY-56	21	CSY056	
CSY-57	27	CSY057	
CSY-57	30	CSY058	

Location	Sample Depth (feet)	epth Project Laboratory Sample		
Fire Train	ing Pits			
FTP-01	21	FTP-001		
FTP-02	24	FTP-002		
FTP-03	24	No sample obtained		
FTP-04	24	FTP-004		
FTP-05	27	FTP-005		
FTP-06	24	FTP-006		
FTP-07	21	FTP-007		
FTP-08	21	FTP-008		
FTP-09	21	FTP-009		
FTP-10	21	FTP-010		
FTP-11	21	FTP-011		
FTP-12	21	FTP-012		
FTP-13	18	FTP-013		
FTP-14	18	FTP-014		
FTP-15	18	FTP-015		
FTP-16	18	FTP-016		
FTP-17	18	FTP-017		
FTP-18	18	FTP-018 (blind duplicate of FTP017)		
FTP-19	21	FTP-019		
FTP-20	18	FTP-020		
FTP-21	18	FTP-021		
FTP-22	18	FTP-022		
FTP-23	18	FTP-023		
FTP-24	18	FTP-024		
FTP-25	15	FTP-025		
FTP-26	15	No sample obtained		
FTP-27	15	FTP-027		
FTP-28	15	FTP-028 (blind duplicate of FTP027)		
FTP-29	18	FTP-029		

Key at end of table.

	Sample Depth		
Location	(feet)	Project Laboratory Sample	
FTP-30	15	FTP-030	
FTP-31	15	FTP-031	
FTP-32	15	FTP-032 (FTP-32 15 feet BGS)	
FTP-33	24	FTP-033 (FTP-32 24 feet BGS)	
FTP-34	33	FTP-034 (FTP-32 33 feet BGS)	
FTP-35	21	FTP-035	
FTP-36	21	FTP-036	
Landfill			
LF-59	12	No samples collected	
LF-60	9	Water levels only	
LF-61	9	Water levels only	

MICROWELL SAMPLE SUMMARY COAL STORAGE AREA OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Location	Sample Depth (feet below drill footing)	Project Laboratory Sample
PS-1	9.9-19.1	PS-1A-CSA
	20.3-29.6	PS-1B-CSA
	30.3-39.6	PS-1C-CSA
PS-2	9.8-19.1	PS-2A-CSA
	19.8-29.1	PS-2B-CSA
	29.8-39.1	PS-2C-CSA
	29.8-49.8	PS-2D-CSA
	49.8-59.1	PS-2E-CSA
	59.8-69.1	PS-2F-CSA
	69.8-79.1	PS-2G-CSA
	79.8-89.1	PS-2H-CSA
	40.3-49.6	PS-1D-CSA
	50.3-59.6	PS-1E-CSA
PS-3	9.7-19	PS-3A-CSA
	19.7-29	PS-3B-CSA
	29.7-39	PS-3C-CSA
	39.7-49	PS-3D-CSA
	49.7-59	PS-3E-CSA
	59.7-60	PS-3F-CSA
	69.7-70	PS-3G-CSA
PS-4	42.1-51.8	PS-4A-CSA
	50.7-60	PS-4B-CSA
	60.7-70	PS-4C-CSA
PS-5	70.7-80	PS-4D-CSA
	80.7-90	PS-4E-CSA
	90.7-100	PS-4F-CSA
	110.7-120	PS-4G-CSA
	120.7-130	PS-4D-CSA
	15.7-25	PS-5A-CSA
	25.7-35	PS-5B-CSA
	35.7-45	PS-5C-CSA
	45.7-55	PS-5D-CSA
	55.7-65	PS-5E-CSA

MICROWELL SAMPLE SUMMARY COAL STORAGE AREA OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Location	Sample Depth (feet below drill footing)	Project Laboratory Sample
PS-5	65.7-75	PS-5F-CSA
	75.6-85	PS-5G-CSA
PS-6	29.7-39	PS-6A-CSA
	39.7-49	PS-6B -CSA
PS-7	9.7-19	PS-7A-CSA
PS-8	9.7-19	PS-8A-CSA
PS-9	9.7-19	PS-9A-CSA
	19.7-29	PS-9B-CSA
	29.7-39	PS-9C-CSA
PS-10	30.7-40	PS-10A-CSA
	50.7-60	PS-10B-CSA
	70.7-80	PS-10C-CSA
	90.7-100	PS-10D-CSA
;	110-120	PS-10E-CSA
	130.7-140	PS-10F-CSA
	150.7-160	PS-10G-CSA
	170.7-180	PS-10H-CSA

Note: Volatile organic compounds by United States Environmental Protection Agency 601/602 on all samples.

Source Area	Location	Sample Depth	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed
FTP	AP-6145	0-6" 0-6" 7' 16'	93FTP090SS 93FTP091SS 93FTP092SB 93FTP093SB	93FTP090SS	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6146	0-6" 12' 22'	93FTP087SS 93FTP088SB 93FTP089SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Dioxin (0-6" only)
	AP-6147	0-6" 12' 12' 19'	93FTP084SB 93FTP081SB 93FTP082SB 93FTP083SB	93FTP081SB	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6148	0-6" 9' 9'	93FTP123SS 93FTP124SB 93FTP125SB	93FTP124SB	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6149	0-6" 9' 9'	93FTP133SS 93FTP132SB 93FTP131SB	93FTP131SB	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6150	0-6" 9' 22'	93FTP126SS 93FTP127SB 93FTP128SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6151	0-6" 11' 15'	93FTP067SS 93FTP079SB 93FTP080SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6152	0-6" 4.5' 14'	93FTP066SS 93FTP069SS 93FTP070SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH

Source Area	Location	Sample Depth	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed
FTP	AP-6153	0-6" 4' 4' 18'	93FTP064SS 93FTP035SB 93FTP036SB 93FTP037SB	93FTP035SB	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Dioxin (at 4' and 18' depth)
	AP-6154	0-6" 9' 19'	93FTP063SS 93FTP019SB 93FTP020SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, Nitrate/Nitrite/Phosphorus (063SS only)
	AP-6155	6.5' 11.5'	93FTP098SB 93FTP099SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP6156	0-6" 0-6" 5' 97'	93FTP104SS 93FTP105SS 93FTP106SB 93FTP108SB	93FTP104SS	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6157	7' 12'	93FTP096SB 93FTP097SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6169	0-6" 17'	93FTP076SS 93FTP001SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, GRO/DRO (0-6" only)
	AP-6170	0-6" 7' 17'	93FTP074SS 93FTP002SB 93FTP003SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6171	0-6" 12' 14.5'	93FTP075SS 93FTP004SB 93FTP005SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6172	0-6" 9.5'	93FTP077SS 93FTP006SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6172	16'	93FTP009SB	None	VOC, BNA, Fuel ID, Pest/PCB, TAL Metals, TOC, TRPH, Dioxin

Source Area	Location	Sample Depth	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed
FTP	AP-6173	0-6"	93FTP071SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6173	10.5' 10.5' 14'	93FTP010SB 93FTP011SB 93FTP012SB	93FTP010SB	VOC, BNA, Fuel ID, Pest/PCB, TAL Metals, TOC, TRPH, Dioxin
	AP-6174	0-6"	93FTP073SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
		11.5'	93FTP013SB	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, TAL Metals, TOC, TRPH, GRO, DRO, Dioxin, Nitrate/Nitrite/Phosphorus
		19.5′	93FTP014SB	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, TAL Metals, TOC, TRPH, Dioxin, Nitrate/Nitrite/Phosphorus
	AP-6175	0-6"	93FTP068SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
		6.5′	93FTP015SB	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, TAL Metals, TOC, TRPH, GRO, DRO, Dioxin, Nitrate/Nitrite/Phosphorus
		9'	93FTP016SB	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-1	0-6"	93FTP021SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-2	0-6"	93FTP022SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-3	0-6"	93FTP023SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-4	0-6"	93FTP024SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-5	0-6"	93FTP025SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-6	0-6"	93FTP026SS 93FTP027SS	93FTP026SS	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH

Source Area	Location	Sample Depth	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed
FTP	SS-7	0-6"	93FTP028SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-8	0-6"	93FTP029SS 93FTP030SS	93FTP029SS	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-9	0-6"	93FTP031SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-10	0-6"	93FTP039SS	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-11	0-6"	93FTP040SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-12	0-6"	93FTP041SS	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-13	0-6"	93FTP042SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-14	0-6"	93FTP043SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-15	0-6"	93FTP044SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-16	0-6"	93FTP045SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-17	0-6"	93FTP046SS 93FTP047SS	93FTP046SS	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity (046SS only), VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-18	0-6"	93FTP048SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-19	0-6"	93FTP050SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-20	0-6"	93FTP051SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-21	0-6"	93FTP052SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-22	0-6"	93FTP053SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-23	0-6"	93FTP054SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH

Source Area	Location	Sample Depth	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed
FTP	SS-24	0-6"	93FTP055SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-25	0-6"	93FTP056SS 93FTP057SS	93FTP056SS	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Dioxin
]	SS-26	0-6"	93FTP058SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-27	0-6"	93FTP059SS 93FTP060SS	93FTP059SS	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, GRO, DRO
	SS-28	0-6"	93FTP061SS	. None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-29	0-6"	93FTP062SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-30	0-6"	93FTP109SS		VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-31	0-6"	93FTP110SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-32	0-6"	93FTP111SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-33	0-6"	93FTP112SS 93FTP113SS	93FTP112SS	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-34	0-6"	93FTP118SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-35	0-6"	93FTP119SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Dioxin
; }	SS-36	0-6"	93FTP120SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Dioxin
	Approximately 7' NE of AP-6152	0-6"	94FTP001SS	None	GRO, DRO, TRPH
	Approximately 7' NW of AP-6152	0-6"	94FTP002SS	None	GRO, DRO, TRPH

Source Area	Location	Sample Depth	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed
FTP	Approximately 4.5' SE of AP-6152	0-6"	94FTP003SS	None	GRO, DRO, TRPH
	Approximately 4.5' NW of AP-6149	0-6"	94FTP004SS	None	GRO, DRO, TRPH
	Approximately 5' W of AP-6149	0-6"	94FTP005SS	None	GRO, DRO, TRPH
	Approximately 4' SW of AP-6149	0-6"	94FTP006SS 94FTP007SS	94FTP006SS	GRO, DRO, TRPH
CSY	AP-6141	0-6" 14' 19'	93CSY020SS 93CSY022SB 93CSY023SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6142	9'	93CSY025SB	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
		19'	93CSY026SB	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Nitrate/Nitrite/Phosphorus
	AP-6144	13' 13' 20'	93CSY057SB 93CSY058SB 93CSY059SB	93CSY057SB	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6158	0-6" 0-6"	93CSY016SS 93CSY017SS	93CSY016SS	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity (016SS only), VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, DRO, GRO, Nitrate/Nitrite/Phosphorus
		20'	93CSY006SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH

Source Area	Location	Sample Depth	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed
CSY	AP-6159	0-6"	93CSY018SS	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Nitrate/Nitrite/Phosphorus
		19' 6.5'	93CSY012SB 93CSY013SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Dioxin
	AP-6160	27.5'a		None	VOC
	_	32'a 44'a		None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Dioxin
	AP-6161	0-6" 0-6"	93CSY028SS 93CSY030SS	93CSY028SS	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
!		11' 11' 20'	93CSY009SB 93CSY010SB 93CSY011SB	93CSY009SB	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity (009SB only), VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, GRO, DRO, Nitrate/Nitrite/Phosphorus
	AP-6162	0-6" 12.5' 17.5'	93CSY019SS 93CSY007SB 93CSY008SB	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity (019SS only), VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6163	16' 19'	93CSY036SB 93CSY037SB	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity (036SB only), VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6164	9' 19'	93CSY039SB 93CSY040SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6165	47'b 59'b	93CSY041SB 93CSY042SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Dioxin
	AP-6166	14' 19'	93CSY053SB 93CSY054SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH

Source Area	Location	Sample Depth	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed
CSY	AP-6167	14' 19'	93CSY048SB 93CSY049SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6168	12' 19'	93CSY050SB 93CSY051SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
Landfill	AP-6130	15' 35'	93LF007SB 93LF008SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6131	0-6"	93LF402SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
		9'	93LF400SB 93LF401SB	93LF400SB	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, DRO, GRO (no DRO, GRO on 401SB)
		12'	93LF404SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6132	0-6" 22'	93LF321SS 93LF002SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6133	0-6" 12' 22'	93LF323SS 93LF009SB 93LF010SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6134	0-6"	94LF322SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6136	0-6"	93LF413SS	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
		14'	93LF422SB	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Nitrate/Nitrite/Phosphorus
		24'	93LF423SB	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH

Source Area	Location	Sample Depth	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed
Landfill	AP-6137	0-6"	93LF013SS 93LF014SS	93LF013SS	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6138	22' 22'	93LF014SB 93LF015SB	93LF014SB	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, GRO, DRO, Nitrate/Nitrite/Phosphorus
		28'	93LF017SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6139	0-6" 9'	93LF015SS 93LF005SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6140	16′	93LF006SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6176	10'	93LF418SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
		23'	93LF419SB	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Nitrate/Nitrite/Phosphorus
	AP-6177	10'	93LF001SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6178	12'	93LF009SB	None	VOC, BNA, Pest/PCB, TOC, TRPH, Fuel ID, Herb, TAL Metals
		22'	93LF010SB	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	AP-6179	22'	93LF414SB	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity
	_	22'	93LF415SB	None	Atterberg Limits, Grain Size, Moisture Content, VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	ASH-1	Surface	93LF001AH	None	BNA, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	ASH-2	Surface	93LF002AH	None	BNA, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	ASH-3	Surface	93LF003AH	None	Atterberg Limits, Grain Size, Moisture Content, BNA, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	ASH-4	Surface	93LF004AH	None	BNA, Pest/PCB, Herb, TAL Metals, TOC, TRPH

SOIL SAMPLE SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Source Area	Location	Sample Depth	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed
Landfill	ASH-5	Surface	93LF005AH	None	Atterberg Limits, Grain Size, Moisture Content, BNA, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	ASH-6	Surface	93LF006AH	None	BNA, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	ASH-7	Surface	93LF007AH	None	Atterberg Limits, Grain Size, Moisture Content, BNA, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	ASH-8	Surface	93LF008AH 93LF009AH	93LF009AH	Atterberg Limits, Grain Size, Moisture Content, BNA, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-1		93LF001SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-2		93LF002SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-3		93LF003SS	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Nitrate/Nitrite/Phosphorus
	SS-4		93LF004SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-5		93LF005SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-6		93LF006SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-7		93LF007SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-9		93LF009SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-10		93LF010SS 93LF011SS	93LF010SS	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-11		93LF012SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-12		93LF019SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-13		93LF020SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-14		93LF026SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH

Key at end of table.
19:JZ5901_S050_T21-06/21/95-D1

SOIL SAMPLE SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Source Area	Location	Sample Depth	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed
Landfill	SS-15		93LF027SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-16		93LF017SS	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, GRO, DRO, Nitrate/Nitrite/Phosphorus
1	SS-17		93LF018SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
∦ .	SS-18		93LF016SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-19		93LF015SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-20		93LF014SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-21		93LF013SS	None	Atterberg Limits, Grain Size, Moisture Content, Specific Gravity, VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-22		93LF021SS 93LF022SS	93LF021SS	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, GRO, DRO, Nitrate/Nitrite/Phosphorus
	SS-23		93LF023SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-24		93LF024SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH
	SS-29		93LF025SS	None	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH

Note: Soil borings/monitoring wells that were not sampled during the remedial investigation do not appear on the table.

a These depths include approximately 16.6 feet of coal.
 b These depths include approximately 28 feet of coal.

Key:

BNA = Base/neutral and acid extractable organic compounds.

CSY = Coal Storage Yard.

DRO = Diesel-range organics.

FTP = Fire Training Pit.

Fuel ID = Fuel identification.

GRO = Gasoline-range organics.

Herb = Herbicides.

NE = Northeast.

NW = Northwest.

Pest/PCB = Pesticides/polychlorinated biphenyls.

QA = Quality assurance.

SE = Southeast.

SW = Southwest.

TAL Metals = Target Analyte List metals.

TOC = Total organic carbon.

TRPH = Total recoverable petroleum hydrocarbons.

VOC = Volatile organic compounds.

W = West.

SEDIMENT/SURFACE WATER SAMPLE SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Source Area	Location	Sediment Project Laboratory Sample	Sediment QA Laboratory Sample	Analyses Performed	Surface Water Project Laboratory Sample	Surface Water QA Laboratory Sample	Analyses Performed
FTP	SD-1	93FTP001SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
	SD-2	93FTP002SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
	SD-3	93FTP003SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
))	SD-4	93FTP004SD 93FTP017SD	93FTP016SD	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
$\left\ \cdot \right\ $	SD-5	93FTP005SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
	SD-6	93FTP006SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Dioxin	N/A	N/A	N/A
	SD-7	93FTP007SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
	SD-8	93FTP008SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Dioxin	N/A	N/A	N/A
	SD-9	93FTP009SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
	SD-10	93FTP010SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
	SD-11	93FTP011SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A

SEDIMENT/SURFACE WATER SAMPLE SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Source Area	Location	Sediment Project Laboratory Sample	Sediment QA Laboratory Sample	Analyses Performed	Surface Water Project Laboratory Sample	Surface Water QA Laboratory Sample	Analyses Performed
	SD-12	93FTP012SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
CSY	SD-13	93FTP013SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
	SD-14	93FTP014SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
	SD-15	93FTP015SD	NA	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
3 / 7	SD-1	93CSY070SD 93CSY071SD	93CSY070SD	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, GRO, DRO	N/A	N/A	N/A
	SD-2	93CSY072SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
L	SD-3	93CSY073SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
	SD-4	93CSY074SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
	SD-5	93CSY062SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	93CSY067SW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TRPH, TPPM, DPPM, TDS/Alkalinity, Major Anions, Major Cations, Nitrate/Nitrite
	SD-6	93CSY065SD	N/A	VOC, BNA, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
	SD-7	93CSY063SD	N/A	VOC, BNA, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Dioxin	N/A	N/A	N/A

Key at end of table. 19:JZ5901_S050-T22-06/21/95-F1

SEDIMENT/SURFACE WATER SAMPLE SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

	Source Area	Location	Sediment Project Laboratory Sample	Sediment QA Laboratory Sample	Analyses Performed	Surface Water Project Laboratory Sample	Surface Water QA Laboratory Sample	Analyses Performed
		SD-8	93CSY064SD	N/A	VOC, BNA, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
		SD-9	93CSY061SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	93CSY066SW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TRPH, TPPM, DPPM, TDS/Alkalinity, Major Anions, Major Cations, Nitrate/Nitrite
		SD-10	93CSY075SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A
2-48	Landfill	SD-1	93LF001SD (0') 93LF002SD (2.5') 93LF003SD (5')	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	93LF001SW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TRPH, TPPM, DPPM, TDS, Alkalinity, Major Anions, Major Cations, Nitrate/Nitrite
-		SD-2	93LF004SD (0') 93LF005SD (2.5') 93LF006SD (5')	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	93LF002SW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TRPH, TPPM, DPPM, TDS/Alkalinity, Major Anions, Major Cations, Nitrate/Nitrite
		SD-3	93LF302SD (0') 93LF304SD (2.5') 93LF305SD (5')	N/A	Grain Size, VOC, BNA, Fuel ID, Pest/ PCB, Herb, TAL Metals, TOC, TRPH, Nitrate/Nitrite/Phosphorus	93LF308SW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TRPH, TPPM, DPPM, TDS/Alkalinity, Major Anions, Major Cations, Nitrate/Nitrite
		SD-4	93LF303SD (0') 93LF306SD (2.5') 93LF307SD (5')	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A

SEDIMENT/SURFACE WATER SAMPLE SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Source Area	Location	Sediment Project Laboratory Sample	Sediment QA Laboratory Sample	Analyses Performed	Surface Water Project Laboratory Sample	Surface Water QA Laboratory Sample	Analyses Performed
	SD-7	93LF316SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	93LF313SW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TRPH, TPPM, DPPM, TDS/Alkalinity, Major Anions, Major Cations, Nitrate/Nitrite
	SD-8	93LF317SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	93LF314SW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TRPH, TPPM, DPPM, TDS/Alkalinity, Major Anions, Major Cations, Nitrate/Nitrite
;	SD-9	93LF336SD 93LF337SD	93LF336SD	Sediment Toxicity (336 only), VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, Nitrate/Nitrite/Phosphorus	93LF335SW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TRPH, TPPM, DPPM, TDS/Alkalinity, Major Anions, Major Cations, Nitrate/Nitrite
	SD-10	93LF341SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	93LF340SW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TRPH, TPPM, DPPM, TDS/Alkalinity, Major Anions, Major Cations, Nitrate/Nitrite
	SD-11	93LF339SD	N/A	Sediment Toxicity, VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH, GRO, DRO	93LF338SW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TRPH, TPPM, DPPM, TDS/Alkalinity, Major Anions, Major Cations, Nitrate/Nitrite
:	SD-12	93LF328SD 93LF330SD	93LF3285D	Sediment Toxicity, VOC, BNA, Pest/PCB, TAL Metals, TOC, TRPH, GRO, DRO	93LF326SW 93LF327SW	93LF326SW	VOC, BNA, Fuel ID, Pest/PCB, Herb, TRPH, TPPM, DPPM, TDS/Alkalinity, Major Anions, Major Cations, Nitrate/Nitrite

SEDIMENT/SURFACE WATER SAMPLE SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Sour Are		Sediment Project Laboratory Sample	Sediment QA Laboratory Sample	Analyses Performed	Surface Water Project Laboratory Sample	Surface Water QA Laboratory Sample	Analyses Performed
	SD-13	93LF332SD	N/A	VOC, BNA, Pest/PCB, TAL Metals, TOC, TRPH	93LF331SW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TRPH, TPPM, DPPM, TDS/Alkalinity,
		93LF342SD		Nitrate/Nitrite/Phosphorus			Major Anions, Major Cations, Nitrate/Nitrite
	SD-14	93LF334SD	N/A	Sediment Toxicity, VOC, BNA, Pest/PCB, TAL Metals, TOC, TRPH	93LF333SW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TRPH, TPPM, DPPM, TDS/Alkalinity, Major Anions, Major Cations, Nitrate/Nitrite
	SD-15	93LF319SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	93LF318SW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TRPH, TPPM, DPPM, TDS/Alkalinity, Major Anions, Major Cations, Nitrate/Nitrite
	SD-16	93LF301SD	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TAL Metals, TOC, TRPH	N/A	N/A	N/A

Table 2-4 (Cont.)

Key:

BNA = Base/neutral and acid extractable organic compounds.

DPPM = Dissolved priority pollutant metals.

DRO = Diesel-range organics.

Fuel ID = Fuel identification.

GRO = Gasoline-range organics.

Herb = Herbicides.

N/A = Not analyzed.

Pest/PCB = Pesticides/polychlorinated biphenyl.

QA = Quality assurance.

SD = Sediment.

SW = Surface water.

TAL Metals = Target Analyte List metals.

TDS = Total dissolved solids.

TOC = Total organic carbon.

TPPM = Total priority pollutants metals.

TRPH = Total recoverable petroleum hydrocarbons.

VOC = Volatile organic compounds.

WA = Water.

GROUNDWATER SAMPLE SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Source Area	Location	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed
FTP	AP-6145	93FTP145GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-6146	93FTP155GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-6147	93FTP154GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-6148	93FTP139GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-6149	93FTP141GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-6150	93FTP152GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, GRO, DRO
	AP-6151	93FTP149GW 93FTP150GW	93FTP149GW	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-6152	93FTP151GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, GRO, DRO
	AP-6153	93FTP153GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-6154	93FTP146GW	N/A	VOC, BNA, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-6155	93FTP143GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-6156	93FTP142GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD



GROUNDWATER SAMPLE SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Source Area	Location	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed
FTP	AP-6157	93FTP144GW	N/A	VOC, BNA, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-6152	93FTP008GW 93FTP010GW	94FTP008GW	VOC, DRO, GRO
	AP-6154	93FTP009GW	N/A	VOC, DRO, GRO
CSY	3595-01	93CSY001GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, dioxin
	3595-02	93CSY002GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, dioxin
	3595-03	93CSY003GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, dioxin
	AP-5508	93CSY083GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-5509	93CSY082GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-5510	93CSY080GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-5511	93CSY081GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-5577	93CSY087GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-5734	93CSY085GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD

GROUNDWATER SAMPLE SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Source Area	Location	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed
CSY	AP-5735	93CSY086GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-5736	93CSY077GW 93CSY078GW	93CSY077GW	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, GRO, DRO
	AP-6141	93CSY096GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-6142	93CSY099GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-6143	93CSY098GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	119	93CSY089GW 93CSY090GW	93CSY089GW	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	3559A	93CSY091GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	3559B	93CYS092GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	99	93CSY093GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD
	AP-6141	94CSY001GW	N/A	VOC, GRO, DRO, dioxins
	AP-6142	94CSY015GW	N/A	VOC, GRO, DRO, dioxins
	AP-6143	94CSY016GW	N/A	VOC, GRO, DRO, dioxins
	AP-6144	94CSY010GW 94CSY011GW	94CSY010GW	VOC, GRO, DRO, dioxins

GROUNDWATER SAMPLE SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Source Area	Location	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed
CSY	AP-6518	94CSY927GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, GRO, DRO
	AP-6519	94CSY026GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, GRO, DRO
	AP-6520	94CSY020GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, DRO
	AP-6521	94CSY025GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, DRO, GRO
	AP-5734	94CSY002GW	N/A	VOC, GRO, DRO, dioxins
	AP-5735	94CSY003GW	N/A	VOC, GRO, DRO, dioxins
	AP-5736	94CSY012GW	N/A	VOC, GRO, DRO, dioxins
	WS-099	94CSY019GW	N/A	VOC, GRO, DRO, dioxins
	WS-119	94CSY017GW 94CSY018GW	94CSY017GW	VOC, GRO, DRO, dioxins
	3595-01	94CSY006GW	N/A	VOC, GRO, DRO, dioxins
	3595-02	94CSY007GW	N/A	VOC, GRO, DRO, dioxins
ļ. :	3595-03	94CSY008GW	N/A	VOC, GRO, DRO, dioxins
	AP-5508	94CSY004GW	N/A	VOC, GRO, DRO, dioxins
	AP-5509	94CSY005GW	N/A	VOC, GRO, DRO, dioxins
	AP-5510	94CSY014GW	N/A	VOC, GRO, DRO, dioxins
	AP-5511	94CSY013GW	N/A	VOC, GRO, DRO, dioxins
	AP-5517	94CSY009GW	N/A	VOC, GRO, DRO, dioxins
	AP-6522	94CSY021GW	N/A	BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, DRO
	AP-6523	94CSY024GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, DRO, GRO

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GROUNDWATER SAMPLE SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Source Area	Location	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed					
CSY	AP-6524	94CSY022GW 94CSY023GW	94CSY022GW	BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, DRO, VOC, GRO					
Landfill	AP-5585	93LF362GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD					
	AP-5588	93LF357GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD					
	AP-5589	93LF366GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, Explos.					
	AP-5591	93LF410GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TD Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, Explos.					
	AP-5593	93LF358GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, Explos.					
	AP-5594	93LF369GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, Explos.					
	AP-6131	93LF426GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, Explos.					
	AP-6132	93LF363GW 93LF364GW	93LF363GW	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, Explos.					
	AP-6133	93LF408GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, Explos.					
	AP-6134	93LF352GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, Explos.					
	AP-6136	93LF428GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, Explos.					

GROUNDWATER SAMPLE SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Source Area	Location	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed
Landfill	AP-6137	93LF355GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, Explos.
	AP-6138	93LF427GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, Explos.
	AP-6139	93LF359GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, Explos.
	FWLF-02	93LF406GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, Explos.
	FWLF-03	93LF409GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, Explos.
	FWLF-04	93LF371GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, Explos.
	WLF-01	93LF347GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, Explos.
	WLF-02	93LF345GW	N/A	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, Explos.
	WLF-03	93LF349GW 93LF351GW	93LF349GW	VOC, BNA, Fuel ID, Pest/PCB, Herb, TPPM, DPPM, TRPH, TOC, TDS, Alkalinity, Major Cations, Major Anions, Nitrate/Nitrite, BOD, GRO, DRO, Explos.
	AP-5585	94LF012GW	N/A	VOC, DRO, GRO
	AP-5588	94LF023W 94LF024W	94LF023W	VOC, DRO, GRO
	AP-5591	94LF021GW	N/A	VOC, DRO, GRO
	AP-5593	94LF005GW 94LF006GW	94LF005GW	VOC, DRO, GRO

GROUNDWATER SAMPLE SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Source Area	Location	Project Laboratory Sample	QA Laboratory Sample	Analyses Performed
Landfill	AP-5594	94LF004GW	N/A	VOC, DRO, GRO
	AP-6132	94LF003GW	N/A	VOC, DRO, GRO
1	AP-6134	94LF014GW	N/A	VOC, DRO, GRO
H	AP-6136	94LF019GW	N/A	VOC, DRO, GRO
	AP-6137	94LF015GW 94LF016GW	94LF015GW	VOC, DRO, GRO
	AP-6138	94LF022GW	N/A	VOC, DRO, GRO
	AP-6139	94LF017GW	N/A	VOC, DRO, GRO
	FWLF-02	94LF011GW	N/A	VOC, DRO, GRO
	FWLF-03	94LF020GW	N/A	VOC, DRO, GRO
1	FWLF-04	94LF018GW	N/A	VOC, DRO, GRO
	FWLF-01	94LF007GW	N/A	VOC, DRO, GRO
	FWLF-02	94LF008GW	N/A	VOC, DRO, GRO
	FWLF-03	94LF000GW	N/A	VOC, DRO, GRO

Key:

BNA = Base/neutral and acid extractable organic compounds.

BOD = Biological oxygen dissolved.

CSY = Coal Storage Yard.

DPPM = Dissolved priority pollutants metals.

DRO = Diesel-range organics.

Explos. = Explosives residue.

FTP = Fire training pit. Fuel ID. = Fuel identification. GRO = Gasoline-range organics.

GW = Groundwater.

Herb = Herbicides

N/A = Not analyzed.

Pest/PCB = Pesticides/polychlorinated biphenyl.

QA = Quality assurance.

TDS = Total dissolved solids.

TOC = Total organic carbon.

TPPM = Total priority pollutants metals.

TRPH = Total recoverable petroleum hydrocarbons.

VOC = Volatile organic compounds.

Table 2-6

GROUNDWATER SAMPLING PARAMETERS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Well No.	Date	pН	Conductivity (µmhos)	Temperature (°C)	Turbidity (NTU)	eH (mV)	DO (mg/L)
Coal Storage Yar	d (1993)						
AP-5508	10-6-93	7.15	349	3.0	3.0	-225	6.50
AP-5509	10-6-93	6.89	423	3.4	11.6	-228	5.50
AP-5510	10-6-93	7.34	295	17.2	1.2	-180	3.90
AP-5111	10-6-93	7.13	303	16.2	1.3	-247	4.10
AP-5517	10-7-93	6.69	826	11.7	118.6	-169	4.60
AP-5734	10-7-93	6.82	377	9.2	63.2	-175	6.20
AP-5735	10-7-93	6.62	510	8.2	45.5	-160	4.90
AP-5736	10-6-93	7.09	322	18.0	4.1	-165	5.10
AP-6141	10-10-93	6.94	291	4.8	30.1	-233	90.0
AP-6142	10-11-93	7.37	316	25.4	60.0	-252	10.80
AP-6143	10-11-93	7.21	327	24.0	45.6	-239	4.80
Fire Training Pit	(1993)						
AP-6145	10-7-93	6.98	302	1.7	NR	303	7.20
AP-6146	10-10-93	6.80	204	1.4	112.0	-233	48.6
AP-6147	10-10-93	6.65	250	4.7	176.0	-222	190.0
AP-6148	10-6-93	7.14	211	2.1	8.0	-240	3.30
AP-6149	10-7-93	7.13	202	4.2	15.2	-240	2.10
AP-6150	10-10-93	7.19	239	6.3	59.6	-250	77.0

GROUNDWATER SAMPLING PARAMETERS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Well No.	Date	рН	Conductivity (µmhos)	Temperature (°C)	Turbidity (NTU)	eH (mV)	DO (mg/L)
AP-6151	10-10-93	6.94	435	5.3	4.7	-230	38.0
AP-6152	10-10-93	7.12	243	2.8	36.0	-266	79.0
AP-6153	10-10-93	7.03	233	2.2	50.1	-233	96.0
AP-6154	10-7-93	6.82	281	4.1	NR	336	5.12
AP-6155	10-7-93	6.92	274	4.3	2.0	-283	3.70
AP-6156	10-7-93	7.12	200	3.0	28.6	-333	9.10
AP-6157	10-7-93	6.86	266	3.4	0.2	282	16.22
Landfill (1993)							
AP-5585	10-5-93	6.95	564	0.7	24.1	-183	6.60
AP-5588	10-5-93	6.77	592	0.4	9.6	-265	7.70
AP-5589	10-6-93	6.63	526	1.0	32.6	-247	5.00
AP-5591	10-11-93	6.50	249	1.2	20.3	-288	3.90
AP-5593	10-5-93	6.67	277	2.6	18.2	-188	6.50
AP-5594	10-6-93	6.60	202	2.5	8.9	-250	5.10
AP-6131	10-26-93	7.87	551	-0.1	5.3	-276	5.90
AP-6132	10-6-93	6.41	210	1.4	15.0	-175	4.00
AP-6133	10-11-93	6.68	443	443 0.5		-233	8.50
AP-6134	10-4-94	7.60	119	0.9	13.4	-220	3.40
AP-6137	10-5-93	6.98	354	2.7	103.0	-211	3.20

Table 2-6

GROUNDWATER SAMPLING PARAMETERS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Well No.	Date	рН	Conductivity (µmhos)	Temperature (°C)	Turbidity (NTU)	eH (mV)	DO (mg/L)
AP-6139	10-5-93	6.62	473	2.5	128.0	-220	2.60
FWLF-2	10-7-93	5.53	74	1.9	4.6	-211	4.00
FWLF-3	10-11-93	6.60	325	1.7	8.5	-251	5.90
FWLF-4	10-7-93	6.56	569	11.5	13.5	-175	6.30
WLF-1	10-3-93	6.06	251	1.4	8.8	-258	12.80
WLF-2	10-3-93	6.06	284	1.9	56.0	-267	12.70
WLF-3	10-4-93	6.65	249	1.5	77.5	-253	13.60
Coal Storage Yar	d (1994)						
AP-6520	7-14-94	NR	520	18.5	0.00	NR	1.39
AP-6522	7-14-94	NR	598	12.7	3.02	NR	1.55
AP-6524	7-14-94	NR	1,311	19.4	0.00	NR	4.71
AP-6518	7-25-94	7.16	360	8.1	2.40	NR	3.36
AP-6519	7-25-94	7.30	580	18.8	0.40	NR	NR
AP-6521	7-25-94	7.20	26	6.4	0.80	NR	4.50
AP-6523	7-25-94	7.20	620	10.0	2.00	NR	NR
99	7-14-94	NR	405	5.1	0.60	-062	4.35
119	7-14-94	NR	431	13.2	1.50	-080	2.40
3595-01	7-13-94	5.20	1,250	7.2	0.00	NR	3.20
3595-02	7-13-94	5.91	1,700	5.5	0.00	NR	3.41

GROUNDWATER SAMPLING PARAMETERS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Well No.	Date	рН	Conductivity (µmhos)	Temperature (°C)	Turbidity (NTU)	eH (mV)	DO (mg/L)	
3595-03	7-13-94	5.57	1,920	6.9	0.00	NR	1.08	
AP-5508	7-14-94	NR	427	6.7	25.8	024	5.46	
AP-5509	7-14-94	NR	542	4.5	19.3	NR	3.35	
AP-5510	7-14-94	NR	200	23.2	6.7	-140	2.02	
AP-5511	7-13-94	6.52	210	23.2	20.6	-023	2.65	
AP-5517	7-13-94	7.08	3	14.2	103.6	069	3.40	
AP-5734	7-14-94	NR	NR	NR NR 0.00 NR		1.29		
AP-5735	7-14-94	NR	NR	NR NR 62.0		NR	1.37	
AP-5736	7-13-94	6.02	207	18.6	25.2	-049	3.20	
AP-6141	7-14-94	NR	213	23.7	0.00	NR	1.05	
AP-6142	7-14-94	NR	194	21.9	1.5	-128	2.20	
AP-6143	7-14-94	NR	192	19.9	48.5	-109	2.08	
AP-6144	7-14-94	6.53	497	22.9	16.6	-064	1.13	
Landfill (1994)								
AP-5585	7-13-94	6.40	1,310	2.2	0.00	-055	1.30	
AP-5585	7-15-94	6.68	1,200	1.7	1.15	-004	NR	
AP-5589	7-15-94	6.76	1,000	3.0	0.00	-040	NR	
AP-5591	7-15-94	NR	NR	NR	200	-004	3.80	
AP-5593	7-11-94	6.56	373	21.4	0.0	-016	NR	

Table 2-6

GROUNDWATER SAMPLING PARAMETERS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Well No.	Date	рН	Conductivity (µmhos)	Temperature (°C)	Turbidity (NTU)	eH (mV)	DO (mg/L)
AP-5594	7-11-94	6.50	264	18.1	24.4	-053	NR
AP-5595	7-15-94	NR	NR	Frozen	NR	NR	NR
AP-6130	7-11-94	NR	NR	Frozen	NR	NR	NR
AP-6131	7-12-94	NR	NR	Frozen	NR	NR	NR
AP-6132	7-11-94	6.32	333	13.6	12.6	013	NR
AP-6133	7-11-94	NR	NR	Frozen	NR	NR	NR
AP-6134	7-15-94	6.92	600 3.1 57.8 -047		NR		
AP-6136	7-11-94	NR	NR	NR	4.25	-076	2.95
AP-6138	7-15-94	6.65	580	3.5	6.38	-095	NR
AP-6139	7-15-94	6.80	870	2.7	0.00	-1.13	NR
FWLF-2	7-12-94	8.48	225	8.3	11.7	-020	NR
FWLF-3	7-15-94	NR	NR	NR	200	-35	3.75
FWLF-4	7-15-94	6.63	119	4.6	1.19	-141	.84
FWLF-1	7-12-94	NR	NR	NR	2.4	-006	1.50
FWLF-2	7-11-94	NR	NR	NR	200	-040	5.20
FWLF-3	7-11-94	NR	NR	NR	200	-012	NR

Table 2-6 (Cont.)

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Key:

2-65

DO = Dissolved oxygen.

eH = Oxidation reduction potential.

 μ mhos = Micromhos.

mV = Millivolts.

mg/L = Milligrams per liter.

NR = Not recorded because of instrument failure.

NTU = Nephelometric turbidity units.

CUSTODY SEAL CODES OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA OCTOBER 1993

Well No.	Seal No.	Well No.	Seal No.
Landfill		Coal Storage Yard	
AP-6130	66503	AP-6141	66533
AP-6131	66504	AP-6142	66529
AP-6132	66505	AP-6143	66528
AP-6133	66507	AP-6144	Unable to seal well
AP-6134	66511	AP-5508	Unable to seal well
AP-6136	66509	AP-5509	Unable to seal well
AP-6137	66512	AP-5510	Unable to seal well
AP-6138	66513	AP-5511	Unable to seal well
AP-6139	66514	AP-5517	66532
AP-6140	66506	AP-5734	66531
AP-5585	Unable to seal well	AP-5735	66530
AP-5588	Unable to seal well	AP-5736	Unable to seal well
AP-5589	Unable to seal well	Fire Training Pits	
AP-5591	Unable to seal well	AP-6145	66524
AP-5593	Unable to seal well	AP-6146	66521
AP-5594	Unable to seal well	AP-6147	66515
AP-5595	Unable to seal well	AP-6148	66516
WLF-1	Unable to seal well	AP-6149	66517
WLF-2	Unable to seal well	AP-6150	66518
WLF-3	Unable to seal well	AP-6151	66519
FWLF-2	66508	AP-6152	66520
FWLF-3	Unable to seal well	AP-6153	66522
FWLF-4	66510	AP-6154	66523
		AP-6155	66526
		AP-6156	66525
		AP-6157	66527

Table 2-8

NEW MONITORING WELL LOCATIONS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Well Number	Northing	Easting	Elevation	Descriptor
Landfill	<u> </u>	<u> </u>		
AP-6130	298062.31	302570.68	455.54	2.8' above ground (MW-1)
AP-6131	297768.37	303774.92	454.14	2.9' above ground (MW-2)
AP-6132	295780.84	304693.51	450.81	2.7' above ground (MW-3)
AP-6133	296628.67	303192.08	444.70	2.3' above ground (MW-5)
AP-6134	294350.85	302373.87	446.77	2.5' above ground (MW-6)
AP-6136	294987.39	301880.98	448.68	2.6' above ground (MW-7)
AP-6137	295036.57	301341.81	439.43	3.2' above ground (MW-8)
AP-6138	294998.75	301341.57	439.83	2.1' above ground (MW-9)
AP-6139	294552.03	301218.40	439.22	2.9' above ground (MW-10)
AP-6140	295387.75	303248.64	448.82	2.8' above ground (MW-11)
Coal Storage Y	'ard			
AP-6141	284587.47	299944.15	443.90	1.80' above ground (MW-1)
AP-6142	286126.39	298294.19	447.89	1.00' above ground (MW-2)
AP-6143	286126.80	298282.96	450.00	2.90' above ground (MW-3)
AP-6144	286002.93	298927.30	448.07	0.29' below ground (MW-4)
AP-6518	286414.46	298220.68	447.31	3.0' above ground (MW-1D)
AP-6519	286431.96	298245.18	445.32	2.8' above ground (MW-1I)
AP-6520	286431.44	298254.15	445.37	2.9' above ground (MW-1S)
AP-6521	286276.44	297597.42	448.05	3.0' above ground (MW-2D)
AP-6522	286267.14	297597.90	448.11	2.9' above ground (MW-2S)
AP-6523	286368.29	299107.95	452.14	3.1' above ground (MW-3D)
AP-6524	286368.95	299095.74	451.86	2.8' above ground (MW-3S)
Fire Training l	Pits			
AP-6145	287152.66	305327.85	450.20	3.4' above ground (MW-1)
AP-6146	286679.63	305972.29	456.33	3.1' above ground (MW-2)
AP-6147	286421.90	307496.06	453.29	3.3' above ground (MW-3)
AP-6148	286896.21	306832.41	447.95	2.7' above ground (MW-4)
AP-6149	286964.14	307000.94	448.85	3.1' above ground (MW-5)
AP-6150	286771.91	307034.22	447.97	2.4' above ground (MW-6)
AP-6151	287069.52	306597.49	448.76	3.1' above ground (MW-7)
AP-6152	287207.80	306299.49	450.93	3.1' above ground (MW-8)
AP-6153	287202.33	305573.51	450.00	3.0' above ground (MW-9)
AP-6154	287200.44	305417.73	451.24	2.9' above ground (MW-10)
AP-6155	287402.90	305265.95	449.87	3.2' above ground (MW-11)
AP-6156	287396.36	305288.01	449.92	3.3' above ground (MW-12)
AP-6157	287389.91	305262.34	449.90	3.2' above ground (MW-13)

3. REGIONAL CHARACTERISTICS

This section describes characteristics of the Fort Wainwright area, including key aspects of the regional meteorology, demography, geology, hydrogeology, and ecology. Location-specific applicable or relevant and appropriate requirements (ARARs) relevant to those topics also are included at the end of this section. Source area specific information is included in Sections 5, 6, and 7.

3.1 METEOROLOGY

Meteorological data for OU-4 were obtained from the United States Department of the Air Force, Detachment 1, 354th Weather Squadron, (PACAF) Fort Wainwright, Alaska. Data for the City of Fairbanks, Alaska, were provided by the National Oceanic and Atmospheric Administration (NOAA), and historical meteorological data for the Fairbanks International Airport were provided by the Arctic Environmental Information and Data Center (Leslie 1991). The data include amounts and types of precipitation, minimum and maximum temperature, wind direction and speed, and barometric pressure.

3.1.1 Precipitation and Temperature

Interior Alaska has warmer summers than any other area in the state (Pewe 1985). The Fort Wainwright area has a continental climate, characterized by an extreme range between summer and winter temperatures. Historically, monthly mean temperatures range from -12.8° F to 61.5° F (see Table 3-1). The historical average high for August is 66.5°F, and the low is 46.5°F. During E & E's August 1993 field activities, the average high was 64°F and the average low was 46°F. September temperatures historically average a high of

54.4°F and a low of 35.4°F. During September 1993 field activities, the average high was 66°F and the average low was 49°F, a difference of 1.4° below normal.

The Fort Wainwright region is characterized as semiarid, with an overall mean annual precipitation of 10.37 inches (Leslie 1991). Approximately 64% of the annual precipitation occurs as rain from May through September. The remaining precipitation occurs as snow and ice, with a mean annual snowfall of 54 inches. Monthly rainfall data are presented in Figure 3-1, with the rainfall averages for the months during RI activities.

3.1.2 Wind Direction and Speed

During most of the year, the prevailing wind direction is from the north at an average of 5.15 miles per hour (mph). However, in June and July, the wind direction is typically from the southwest at an average of 6.9 mph (Leslie 1991). The strongest winds occur in May and June. A summary of wind direction and maximum speed for August 17 through September 30, 1993, is provided in Figure 3-2.

3.1.3 Water Balance

Evapotranspiration in the region varies depending on the type of vegetation, temperature, humidity, available soil moisture, and precipitation. Evapotranspiration rates from June 1982 to June 1984 for two watersheds (Ester Creek and Happy Creek) located west of Fairbanks were 9.8 inches per year and 9.5 inches per year, respectively (Gieck and Kane 1986). Though not specifically measured during previous studies, another component of the water balance is sublimation, which is an evaporation process for snow and ice.

Streamflow data from the Chena River at Fairbanks (recorded since 1948) indicate that the annual runoff for the Chena Basin is 10.02 inches per year. Using an estimate of 6 inches per year for the basinwide average evapotranspiration, this corresponds to an average precipitation of approximately 16 inches per year for the entire Chena River basin.

Gieck (1986) summarized the general water balance for the Fairbanks area based on observations made at local watersheds:

• The snowmelt period is the main time for significant groundwater recharge, a time of net gain in area water resources. The water balance during this time is dominated by high runoff. A steady input of meltwater from the winter's accumulation of snow and low

- evaporation rates provides significant groundwater recharge, despite reduced infiltration rates of frozen soils caused by seasonal frost;
- The summer-fall season is dominated by high rates of potential evapotranspiration (PET). The summer-fall season is one of net loss to the area's water resources. Light precipitation and high evapotranspiration (EVT) rates keep early and midsummer potential groundwater recharge low. Given sufficient precipitation, groundwater recharge may occur in the late summer-fall as PET rates decline. Areas of higher elevation, where EVT is lower and precipitation greater, are more likely to have significant groundwater recharge;
- Winter is dominated by baseflow. All precipitation is stored temporarily at the surface as ice or snow. Without inputs, winter is characterized by significant water loss in the watersheds studied; and
- The upper elevations (above 2,000 feet) of the Yukon-Tanana Uplands may receive twice the precipitation observed by the National Weather Service at the International Airport. Monthly PET decreased by about 10% per 1,000 foot increase in elevation, and the average environmental lapse rate was 4.6°F per 1,000 feet.

3.2 DEMOGRAPHY AND LAND USE

The City of Fairbanks is in central Alaska in the North Star Borough and is surrounded by vast areas that generally are uninhabited. Most of the City of Fairbanks lies within 4 miles of the OU-4 source areas.

4.7°1

The Fairbanks/North Star Borough has a population of 77,720 (United States Department of Commerce 1990). Military personnel from Eielson Air Force Base and Fort Wainwright make up much of the total Fairbanks population of 28,854 (City Clerks Office 1991). A total of 11,775 people reside at Fort Wainwright. Workers at the Fort include 5,085 soldiers, 701 Department of Army civilians, and 871 other civilians (Douglas 1994). According to the most recent census, 1,456 people live in the city of North Pole (United States Department of Commerce 1990).

The CSY is in an area, on Fort Wainwright, classified as industrial park, where services such as warehousing, utilities, and maintenance are provided. The CSY is less than 0.25 mile from the Post Center, where functions such as the Post Exchange, recreation, and troop barracks are provided. This area has high pedestrian and vehicular activity and is the hub of Fort Wainwright (Higginbotham/Briggs & Associates 1991).

The Landfill is north of the Chena River and is separated from the Fairbanks city limits by Birch Hill. The Landfill lies approximately 1.25 miles east of the 801 Housing Subdivision (Birchwood) on Fort Wainwright. This subdivision houses 1,580 residents (Douglas 1994).

The FTPs are in the area, south of Ladd Field, classified as industrial. The nearest residences to the FTPs are in the Clear Creek Park Subdivision approximately 1.5 miles east of the FTPs Source Area.

3.3 GEOLOGY

3.3.1 Regional Geology

Fort Wainwright lies upon floodplain alluvial deposits of the Tanana River and the Chena River. The Fort Wainwright area has not been impacted directly by glaciation, though glaciers from the Alaska Range to the south reportedly approached to within 50 miles. These glaciers caused rapid aggradation of the Tanana River valley and associated tributary valleys (Nelson 1978).

The Tanana-Chena floodplain was formed by the glacier-fed Tanana River and the smaller Chena River. The elevation of the floodplain in the Fort Wainwright area ranges between 440 to 500 feet, and slopes west to northwest at approximately 5 feet per mile (USGS 1971).

On Fort Wainwright, the Tanana-Chena floodplain is underlain by 10 feet to more than 400 feet of unconsolidated silt, sand, and gravel alluvial deposits (Pewe *et al.* 1976). The ground surface is mantled typically by 1 to 15 feet of silt and fine-grained sand above an extensive sand and gravel outwash deposit in a buried river valley that is incised into bedrock.

Bedrock underlying the Fort Wainwright area and exposed in the highlands north of the Chena River (Birch Hill) consists of late Precambrian to early Paleozoic schists and quartzites (metamorphic rocks) of the Yukon-Tanana terrain. The bedrock is predominantly a metamorphosed marine mud deposit, termed a pelitic schist (the Birch Creek schist). Where the marine mud deposit graded into what were limy mud, calcium carbonate deposits, and quartz sands, metamorphic processes produced calcium-mica schists, marbles, and quartzite, respectively. The schist is intruded locally by granitic rocks (mainly granite and quartz diorite). Basalt also occurs in scattered outcrops east of Fort Wainwright (Nelson 1978).

3.3.2 Permafrost

The Fort Wainwright area is underlain by discontinuous permafrost of generally low ice content in nonorganic soils. The ice is restricted typically to pore spaces and to thin ice seams in the silts and clays. The depth to permafrost, when present, ranges from 2 to 40 feet BGS. The greater depths are found on cleared and developed land surfaces where thermal degradation of underlying permafrost is occurring. The thicknesses of the permafrost intervals vary from approximately 5 to 275 feet. The seasonal frost layer (or active layer) also varies in thickness and is typically between 2 to 12 feet in areas where permafrost does not occur near the surface. Unfrozen masses of subsurface material, known as taliks, may be found within a body of permafrost. Large masses of ground ice in various geometric shapes and origins may be found in the upper part of the permafrost layer. In some instances, more than half the volume of the upper 10 feet of the permafrost layer consists of ice. The ice may occur as coating, individual crystals, ice wedges, and/or veinlets and lenses.

Rates of groundwater movement in frozen porous materials depend on the overall temperature of the system, the thermal gradient, the available cross sectional area of interconnected films of unfrozen water, and the general continuity of the permafrost. Previous studies indicate that permafrost containing large, interconnected films of unfrozen water is most likely to be composed of fine-grained materials (silt and clay sizes). Permafrost should not be regarded as an impermeable material, but rather as a material of very low hydraulic conductivity that is similar to clay (Sloan and van Everdingen 1988). According to CRREL, no clear-cut terrain features or vegetation changes observed at Fort Wainwright correlate with the distribution of permafrost, permafrost depth, or thickness, with, perhaps, the exception of the Landfill Source Area. This may result from the floodplain's complex depositional and erosional history, the insufficiently known climatic history of the region, and other factors such as surface modifications (Lawson et al. 1994).

3.4 REGIONAL HYDROGEOLOGY

This section describes the regional hydrogeology in the Fort Wainwright area and how it relates to surface waters. Detailed descriptions of the hydrogeology at each source area are presented in Sections 5, 6, and 7.

The main aquifer in the Fort Wainwright area is an alluvial aquifer comprising unconsolidated silts, sands, and gravels in a buried river valley. This aquifer ranges from a few

feet thick at the base of Birch Hill to at least 400 feet thick under the Main Cantonment Area of the fort. The aquifer may reach thicknesses of up to 700 feet in the Tanana River valley (WCC 1990). According to the Corps, the aquifer appears to be a single unconfined, completely saturated, high-yielding aquifer containing discontinuous permafrost (USACE 1986). Pumping tests conducted in the aquifer yield values of transmissivity ranging from 100,000 to 300,000 gallons per day per foot (gpd/ft) and specific yield values of 0.07 to 0.56 (dimensionless; WCC 1989).

Seasonal groundwater elevations measured at different depths throughout the Tanana-Chena River regional floodplain indicate that shallow groundwater flow is mainly horizontal with an average hydraulic gradient of 0.0007 feet per foot (ft/ft; 4 feet per mile [ft/mile]; USGS 1990). North of the Chena River at the base of Birch Hill, groundwater appears to flow in a general west-southwest direction in response to baseflow off of Birch Hill. The groundwater flow direction in the immediate vicinity of the Chena River is generally westward but locally is toward the river during periods of low stage, and away from the river during periods of high stage. The stage elevations are seasonally variable and dependent on precipitation events.

Groundwater movement between the Tanana and Chena rivers generally follows a northwest regional pattern but fluctuates seasonally because of the effects of changing river stages in the Tanana River and, to a lesser extent, in the Chena River. Although the stage of the Chena River is controlled by the Corps at Moose Creek Dam to prevent flooding of the Fairbanks area, seasonal fluctuations in levels do occur. Figure 3-3 presents stage levels of the Chena and Tanana rivers and the groundwater elevation of USGS monitoring well 113, screened from 100 to 113 feet BGS, on Fort Wainwright (USGS 1994).

High stages of the Tanana River during summer are derived from melting snow and ice. During high flows in the Tanana River, the hydraulic gradient at the Tanana River is typically greater than that at the Chena River, resulting in a northerly shift in the groundwater flow direction during summer. During winter, the relatively higher Chena River stage imparts a westerly component of groundwater flow and causes the local groundwater direction to shift more to the west than to the northwest. In addition to these prominent effects on the groundwater flow direction in the alluvial aquifer, groundwater levels may be affected locally by pumping in gravel mining areas situated throughout the floodplain. This pumping effect has been noticed outside Fort Wainwright (USGS 1990).

The hydraulic gradient in the alluvial aquifer at Fort Wainwright ranges from 0.0015 to 0.005 ft/ft (7.92 to 26.4 feet per mile). Data accumulated over 15 years indicate water table fluctuations during that period to be about 5.5 feet. However, annual fluctuations from 2 to 3 feet were observed and are considered typical at the fort (USACE 1991).

Groundwater levels near the Chena River tend to fluctuate to a greater degree depending on the stage of the river. Observed influences of the Chena and Tanana rivers on USGS monitoring well 113 are shown in Figure 3-4. Typically, groundwater levels increase when the river stage increases, particularly during spring breakup and late summer runoff. A decrease is observed during fall and winter when water is stored as snow and ice. Effects of the Tanana River are less distinct because of the distance of the Tanana River from the monitoring well (USGS 1990, 1994).

Groundwater in the Tanana-Chena floodplain generally exists under unconfined conditions. Semiconfining or confining conditions may develop seasonally where the depth to the water table is less than the depth of the seasonal frost penetration, or permanently confining or semiconfining conditions may develop where the depth to the water table is less than the depth to permafrost.

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Where present, permafrost forms discontinuous, semiconfining layers that influence groundwater movement and distribution. The presence of near-surface permafrost usually restricts groundwater movement within the shallow subsurface. The distribution and effect of permafrost on the hydrogeology at each Source Area is explained in detail in Sections 5, 6, and 7.

Three types of aquifers are associated with permafrost. A suprapermafrost aquifer is situated above the permafrost table in the active layer; the permafrost table acts as a relatively impermeable basal boundary. Intrapermafrost aquifers are found in unfrozen talik zones within the body of permafrost. Subpermafrost aquifers are situated below the permafrost, with the permafrost serving as a relatively impermeable upper boundary. The suprapermafrost aquifers are normally seasonal aquifers, freezing or experiencing significant storage depletion during winter. Several monitoring wells at the fort and some domestic wells are completed in this aquifer. Intrapermafrost aquifers can be found in unfrozen zones completely surrounded by permafrost; in lateral unconfined taliks; and in isolated, completely confined taliks. The subpermafrost aquifers are found in alluvial deposits below river valleys and are used widely as sources of water supply in the Yukon and Tanana river basins (Williams and

van Everdingen 1973). Many of the municipal water supply wells for Fairbanks and Fort Wainwright are completed in the subpermafrost aquifer in the floodplain.

All three types of aquifers appear to exist in the Landfill Source Area. Suprapermafrost and subpermafrost aquifers may be present at the FTPs, although no deep monitoring wells identified significant permafrost. Suprapermafrost and subpermafrost aquifers may exist at the CSY Source Area, although the monitoring wells installed during the field activities did not encounter permafrost. Permafrost was identified in previously completed borings north of the CSY (Pewe and Bell 1975).

3.4.1 Regional Groundwater Quality and Hydrogeochemistry

In general, chemical constituent concentrations in groundwater in the Fort Wainwright area comply with National Interim Primary Drinking Water Regulations (NIPDWR) standards (EPA 1981a) and National Secondary Drinking Water Regulations (NSDWR) standards (EPA 1981b). The main deviations from state and federal standards are naturally occurring high levels of iron and manganese. The alluvial groundwater is generally an alkaline, moderately hard to hard, calcium bicarbonate type groundwater having low to moderate amounts of total dissolved solids (TDS; Cederstrom 1963).

In a study performed by the USGS, water samples from domestic observation wells 4 miles upgradient (east-southeast) of Fort Wainwright were characterized for chemical constituents. The samples were analyzed for iron, hardness, arsenic, nitrate, chloride, phosphorus, sulfate, and fecal coliform. Only iron was found in concentrations above EPA secondary contaminant levels for domestic water supplies. Iron concentrations ranged from 0.07 to 73 mg/L, with an average iron concentration of 8.37 mg/L. The EPA secondary maximum contaminant level for iron is 0.3 mg/L. Elevated arsenic levels also are common in the Fairbanks region, particularly in upland areas. Of 94 wells tested in 1982, none of the sample concentrations were above EPA's current 50 μ g/L standard, although 27 samples were above the 10 μ g/L risk-based concentration (RBC) for ingestion (Hazard Index = 1; EPA 1991). The average arsenic concentration in these wells was 23.75 μ g/L (Krumhardt 1982). Table 3-2 summarizes the results from the survey. Elevated levels of arsenic, nitrates, and hardness are reported commonly in the Fairbanks area and result from both natural and manmade processes. Sulfate is occasionally high, while chloride and fluoride are found normally in low concentrations (Cederstrom 1963; Johnson *et al.* 1978).

A statistical study on groundwater and soil samples collected in the Fort Wainwright area was completed by the Corps at the direction of the Army to determine appropriate background levels for arsenic, barium, cadmium, chromium, and lead (Corps 1994). The data and statistical approach used by the Corps and the conclusions drawn in this report were reviewed and accepted by the Army, EPA, and ADEC. The report calculated a 95% upper confidence limit (UCL) for use in the determination of added risk from inorganic contamination for areas on Fort Wainwright. The summary found that similar concentrations of the inorganic elements were detected in groundwater samples collected from north and south of the Chena River. Analytical inorganic results for soil samples indicate that the soils north and south of the Chena River are statistically different, but that there were no noticeable differences in inorganic concentration with depth. The results are summarized in Table 3-3.

Permafrost can have a significant effect on the quality of groundwater. Reactions and dissolution rates are reduced under seasonal and perennial low temperature conditions prevailing in permafrost areas, but reduced rates of groundwater movement provide for a longer residence time, during which reactions can occur between the groundwater and the aquifer materials. In addition, solubilities of calcium and magnesium bicarbonate are somewhat increased because of increased solubility of carbon dioxide at lower temperatures.

Suprapermafrost aquifer waters are influenced by near-surface infiltration of water from precipitation, snowfall, runoff, etc. Such aquifers are commonly high in TOC and, where in contact with intra- and subpermafrost waters, may be high in TDS. Intrapermafrost waters may be similar in composition to either supra- or subpermafrost. Taliks commonly contain large concentrations of dissolved metals. Subpermafrost waters range in chemical composition, depending principally on the residence time of the water in the ground, and on the mineral composition of the aquifers (Sloan and van Everdingen 1988). For example, areas of melting ice and ice lenses in permafrost are typically low in dissolved minerals, especially carbonates and sulfates that were precipitated during the initial freezing. Subpermafrost water can range from fresh water of the calcium magnesium carbonate type, to brackish, sulfurous, and saline water, to sodium chloride or calcium/sodium chloride brines.

3.4.2 Regional Water Supply

Three Fairbanks MUS wells are 1 to 2 miles west of Fort Wainwright south of the Chena River. The Fairbanks MUS wells are screened approximately 65 to 75 feet BGS (E & E 1990). Four public supply wells serving the Fort Wainwright area are near the CSY (wells AP-3559A, AP-3559B, AP-3565, and AP-3595) and are screened at approximately 100, 100, 202, and 179 feet BGS, respectively (USACE 1992). The MUS wells and Fort Wainwright wells serve approximately 15,720 and 12,700 people, respectively (MUS 1991; Tryck 1987). In addition, there is a drinking water well at the Birch Hill ski lodge on Fort Wainwright, and nonpotable water wells at the Fairbanks Fuel Terminal and at the Landfill on Fort Wainwright. The well at the Fairbanks Fuel Terminal was abandoned during 1993 field activities. Drinking water wells are in the Lakeview Drive and Lakeview Terrace subdivisions, south of the Chena River. East of Fort Wainwright, drinking water wells are in the Dennis Manor Subdivision, Six Mile Village, and Badger Road Trade Center, and on the Richardson Highway. West of Fort Wainwright are the Pioneer wells in the Hamilton Acres Subdivision, and the wells at the Shannon Park Baptist Church and the Mormon Chapel. In addition, there are drinking water wells northwest of Fort Wainwright on McGrath Road, Chena Hot Springs Road, and the Old Steese Highway on the north side of Birch Hill.

3.5 ECOLOGY

The Fort Wainwright area lies within an upland spruce-hardwood forest ecosystem (Joint Federal Studies 1976). Natural vegetation in the area is typical of the low elevations in interior Alaska. Tree species in undeveloped areas include paper birch, white spruce, black spruce, quaking aspen, balsam poplar, and tamarack. Willows, alders, dwarf birch, rose, blueberry, labrador tea, and high brush cranberry are common shrubs (Alaska Department of Transportation 1979). Black spruce dominates the lowland forests, which are found generally on shallow peat, glacial deposits, outwash plains, and north-facing slopes or where permafrost occurs near the ground surface (Selkregg 1976). Natural plant succession in the fort area is influenced mostly by soil drainage and nutrient content.

Nearly all of the natural vegetation and original topsoil at Fort Wainwright was stripped before construction of the base facilities. Gravel was used extensively as backfill. Topsoil was replaced in many areas to create lawns, playfields, and landscaped areas (USKH 1983).

Wildlife species found in the area surrounding Fairbanks are similar to those found in other areas of interior Alaska (ADOT 1979). In the immediate vicinity of Fairbanks, mammals and birds that tolerate human presence are common (ADOT 1979). A waterfowl nesting area exists less than 6 miles west of the Fairbanks airport (JFS 1976). The City of Fairbanks lies within a winter use and calving area for moose, and within a general distribution area for brown bear (Alaska Department of Fish and Game 1985). Fort Wainwright has been documented as a habitat for moose, red fox, muskrat, beaver, snowshoe hare, red squirrel, and marten, and black bear are reported occasionally (USKH 1983). The only known listed endangered species in the area is the peregrine falcon, whose nesting grounds nearest Fort Wainwright are approximately 12 miles southwest of Fairbanks in T2S, R3W (Garret 1991).

Migratory waterfowl, including ducks, geese, and swan, are present at Fort Wainwright, and they make use of many ponds and wetlands in the vicinity (Kerns 1993). Other migratory birds include swallows, thrushes, sparrows, sandpipers, yellowlegs, and warblers. Raptors include bald and golden eagles, peregrine falcons, hawks, merlins, and kestrels. Great horned, great gray, snowy, and boreal owls are present. Nonmigratory birds at Fort Wainwright include ravens, jays, chickadees, woodpeckers, grouse, and ptarmigan (USKH 1983).

3.6 LOCATION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Listed below are location-specific applicable or relevant and appropriate requirements (ARARs) that may affect remedial actions for the OU-4 source areas. Numerous other location-specific requirements also were evaluated (i.e., Wild and Scenic River Act, Fish and Wildlife Coordination Act, Migratory Bird Treaty Act, and Fish and Wildlife Improvement Act). However, based on the preliminary list of remedial action alternatives identified in the Management Plan, these requirements are not considered potential ARARs for OU-4 at this time.

3.6.1 Resource Conservation and Recovery Act

Forty Code of Federal Regulations (CFR) 264.18 contains a number of explicit limitations on where on-site storage, treatment, and disposal of hazardous waste may occur. In particular, 40 CFR 264.18(b) contains limitations on facility siting in floodplains.

3.6.2 Clean Water Act Section 404

Section 404 of the Clean Water Act, which is implemented by EPA and the Corps through regulations in 40 CFR 230 and 33 CFR 320 to 330, prohibits the discharge of dredged or fill material into "waters of the United States" without a permit. Although CERCLA on-site actions do not require a permit, the substantive requirements of Section 404 and the implementing regulations are potential ARARs for remedial actions that could impact wetlands.

3.6.3 National Historic Preservation Act (16 United States Code 470)

The National Historic Preservation Act (NHPA) and its implementing regulations in 36 CFR 800 require that federal agencies take into account the effects of remedial activities on historic properties included on or eligible for inclusion on the National Register of Historic Places. The National Register is a list of districts, sites, buildings, structures, and objects that are significant in American history, architecture, archaeology, engineering, and culture. Although most provisions of this law are considered to be administrative and, therefore, are not ARARs (i.e., documentation and consultation with regulatory agencies), EPA strongly recommends that these administrative procedures be followed. In particular, the requirements of the NHPA will be considered during remedial action at the base of Birch Hill, where the presence of archaeological resources is suspected (Reynolds 1994).

3.6.4 Archaeological and Historical Preservation Act (16 United States Code 469a-1)

This act provides for the preservation of historical and archaeological data that might otherwise be lost as a result of alterations of the terrain. If any remedial actions could cause irreparable loss to significant scientific, prehistorical, or archaeological data, the act requires the agency undertaking the project to preserve the data or request the Department of Interior (DOI) to do so. This act differs from the NHPA in that it encompasses a broader range of resources than those listed on the National Register and mandates only the preservation of the data. Although most provisions of this law are considered to be administrative and, therefore, are not ARARs (i.e., documentation and consultation with regulatory agencies), EPA strongly recommends that these administrative procedures be followed. In particular, the requirements of the NHPA will be considered during remedial action at the base of Birch Hill, where the presence of archaeological resources is suspected.

3.6.5 Endangered Species Act (16 United States Code 1531)

The Endangered Species Act (ESA) and its implementing regulations in 50 CFR 402 provide a means for conserving various species of fish, wildlife, and plants that are threatened with extinction. The ESA defines an endangered species as "any species which is in danger of extinction throughout all or a significant portion of its range ..." In addition, the ESA defines a threatened species as "any species which is likely to become an endangered species within the foreseeable future ..." Furthermore, the ESA provides for the designation of critical habitats that are "specific areas within the geographical area occupied by the [endangered or threatened] species ... on which are found those species ..."

Section 7(a) of the ESA requires federal agencies, in consultation with DOI and the National Marine Fisheries Service (NMFS), as appropriate, to ensure that the actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their critical habitats. Actions that might jeopardize listed species include direct and indirect effects, as well as the cumulative effects of other actions that are interrelated or interdependent with the proposed action.

Substantive compliance with the ESA means that the lead agency must identify whether a threatened or endangered species, or its critical habitat, will be affected by a proposed response action. If so, the agency must avoid the action or take appropriate mitigation measures so that the action does not affect the species or its critical habitat. If, at any point, the conclusion is reached that endangered species are not present or will not be affected, no further action will be taken. The only endangered species in the Fort Wainwright area is the peregrine falcon, which nests approximately 12 miles southwest of Fairbanks. The potential impact to the peregrine falcons by sources or actions at the FTPs will be evaluated in the ecological risk assessment.

Table 3-1

CLIMATIC NORMALS, MEANS, AND EXTREMES
1949 - 1991
FAIRBANKS, ALASKA

Condition	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Normal Temperature °F													
Normals								·			ŀ	ŀ	
- Daily Maximum	-3.9	7.3	21.7	40.8	59.2	70.1	71.8	66.5	54.4	32.6	12.4	-1.7	35.9
- Daily Minimum	-21.6	-15.4	-4.8	19.5	37.2	48.5	51.2	46.5	35.4	17.5	-4.6	-18.4	1.59
- Monthly	-12.8	-4.0	8.5	30.2	48.2	59.3	61.5	56.6	44.9	25.0	3.9	-10.1	25.9
Extreme Temperature °F											_		
- Record Highest	50	47	51	74	89	96	94	90	84	65	46	44	96
- Year	1981	1987	1987	1960	1960	1975	1975	1976	1957	1969	1985	1985	June 69
- Record Lowest	-61	-56	-49	-24	-1	35	35	27	10	-27	-62	-62	-62
- Year	1969	1968	1956	1986	1964	1959	1959	1987	1983	1975	1961	1961	Dec. 61
Avg. Pressure (mb)	993.6	995.9	993.1	993.3	992.5	993.4	995.6	995.5	992.7	989.8	991.6	993.0	993.3.
Precipitation (inches)													
Water Equivalent												Ì	1
- Normal	0.53	0.42	0.40	0.27	0.57	1.32	1.77	1.86	1.09	0.74	0.67	0.73	10.37
- Maximum Monthly	1.92	1.75	2.10	0.93	1.67	3.52	4.87	6.20	3.05	2.19	3.32	3.23	6.20
- Year	1957	1966	1963	1982	1955	1955	1990	1967	1960	1983	1970	1984	Aug. 67
- Minimum Monthly	0.01	0.01	Т	Т	0.07	0.19	0.40	0.40	0.15	0.08	Т	Т	Т
- Year	1966	1976	1987	1969	1957	1966	1957	1957	1968	1954	1953	1969	Mar. 87
- Maximum in 24 hours	0.58	0.97	0.92	0.47	0.88	1.52	1.73	3.42	1.21	2.22	0.84	1.25	3.42
- Year	1968	1966	1963	1979	1955	1955	1990	1967	1954	1976	1970	1968	Aug. 67
Snow, Ice Pellets													1
- Maximum Monthly	26.3	43.1	29.6	11.4	4.7	Т	Т	7.8	25.9	54.0	50.7	50.7	54.0
- Year	1957	1966	1963	1982	1964	1990	1969	1972	1982	1970	1984	1984	Nov. 70
- Maximum in 24 hours	9.4	20.1	12.6	5.8	4.5	Т	Т	7.0	10.4	14.6	14.7	14.7	20.1
- Year	1968	1966	1963	1982	1964	1990	1969	1972	1974	1970	1968	1968	Feb. 66

Table 3-1

CLIMATIC NORMALS, MEANS, AND EXTREMES 1949 - 1991 FAIRBANKS, ALASKA

Condition	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Wind													
Mean Speed (miles per hour) Prevailing direction	3.1	4.0	5.3	6.6	7.7	7.2	6.6	6.2	6.2	5.4	3.8	3.2	5.4
through 1963	N	N	N	N	N	sw	sw	N	N	N	N	N	N
Fastest Observed 1 Minute													
- Direction	03	27	22	24	23	25	27	27	22	25	25	24	25
- Speed (miles per hour)	29	33	40	32	32	40	32	34	30	40	35	37	40
- Year	1983	1955	1970	1983	1983	1974	1989	1954	1975	1958	1970	1970	June 74
Peak Gust													
- Direction	sw	sw	sw	w	sw	E	NE	s	w	sw	sw	sw	NE
- Speed (miles per hour)	39	40	46	31	38	43	63	38	51	28	35	38	63
- Date	1989	1989	1985	1990	1986	1985	1990	1985	1985	1986	1990	1985	July 90

Key:

°F = Degrees Farenheit.

mb = millibars.

N = North.

SW = Southwest.

Source: Alaska Climate Series, 2nd Edition, 1991, Arctic Environmental Data Center.

Table 3-2

BACKGROUND GROUNDWATER CHEMICAL PARAMETERS

OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

1041 ***********************************						
	Number of Observations	Mean	S.D.	Min.	Max.	
Specific Conductance (µmho/cm @ 25°C)	94	390.51	89.45	245	725	
Temperature (°C)	94	3.99	2.8	0.5	15.0	
рН	94	7.089	0.335	6.4	8.4	
Hardness (as CaCO ₃)	88	7.089	43.88	110	340	
Alkalinity (as CaCO ₃₎	94	184.2	50.5	111	412	
Dissolved Sulfate (mg/L)	77	13.84	10.86	0.4	39.0	
Dissolved Chloride (mg/L)	74	6.25	7.98	0.03	35.0	
Dissolved Nitrate (NO ₂ /NO ₃ as N; mg/L)	35	3.08	53	0.00	2.1	
Total Nitrate (NO ₂ /NO ₃ as N; mg/L)	44	3.02	0.088	0.00	0.54	
Total NH ₄ (mg/L)	44	3.258	.247	0.03	1.1	
Dissolved Phosphorus as P (mg/L)	33	.033	0.44	0.00	0.10	
Total Phosphorus (ortho) as P (mg/L)	44	0.45	0.6	0.00	0.28	
Total Arsenic (µg/L)	94	7.7	6.37	0.0	44	
Total Iron (mg/L)	87	8.37	12.58	0.07	73	

Key:

CaCo₃ = Calcium carbonate.

 $\mu g/L$ = Micrograms per liter.

 μ mho/cm = Micromhos per centimeter.

mg/L = Milligrams per liter.

Mean = Mean of the reported value.

Min. = Minimum value.

Max. = Maximum value.

N = Nitrogen.

NH₄ = Ammonia.

NO₂/NO₃ = Nitrate/Nitrite.

 $\mathbf{\tilde{P}} = \mathbf{Phosphorus}$.

S.D. = Standard deviation of the reported value.

Source: Frumhardt 1982.

Table 3-3

RECOMMENDED BACKGROUND VALUES FOR FORT WAINWRIGHT UNITED STATES ARMY CORPS OF ENGINEERS MARCH 1994

RCRA Metal	Matrix	Value± Standard Deviation				
South of Chena River						
Arsenic	Soil	8 ± 6 mg/kg				
Barium	Soil	85 ± 30 mg/kg				
Cadmium	Soil	1 ± 0.8 mg/kg				
Chromium	Soil	15 ± 4 mg/kg				
Lead	Soil	11 ± 15 mg/kg				
North of Chena River						
Arsenic	Soil	11 ± 6 mg/kg				
Barium	Soil	154 ± 121 mg/kg				
Cadmium	Soil	1 ± 0.7 mg/kg				
Chromium	Soil	26 ± 9 mg/kg				
Lead	Soil	13 ± 12 mg/kg				
North and South of Chena River						
Arsenic	Water (total)	36 ± 36 μg/L				
Barium	Water (total)	551 ± 437 μg/L				
Cadmium	Water (total)	5 ± 4 μg/L				
Chromium	Water (total)	53 ± 72 μg/L				
Lead	Water (total)	34 ± 32 μg/L				
Arsenic	Water (dissolved)	9 ± 11 μg/L				
Barium	Water (dissolved)	250 ± 91 μg/L				
Cadmium	Water (dissolved)	3 ± 1.8 μg/L				
Chromium	Water (dissolved)	4 ± 2 μg/L				
Lead	Water (dissolved)	5 ± 4.9 μg/L				

Key:

 μ g/L = Micrograms per liter.

mg/kg = Milligrams per kilogram.

RCRA = Resource Conservation and Recovery Act.

PLATE

DATE:

94OCT6

JOB. NO.

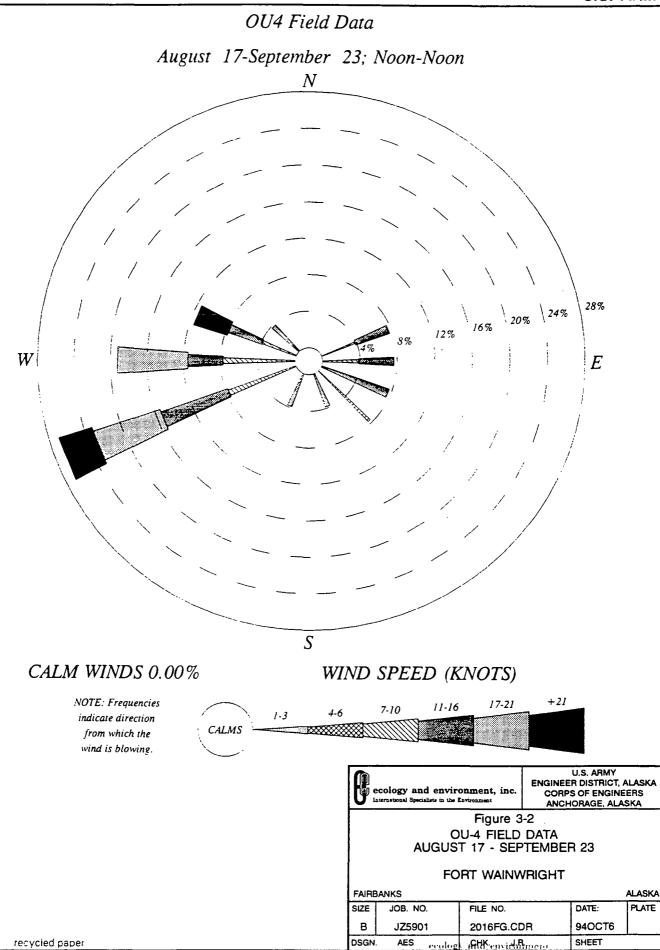
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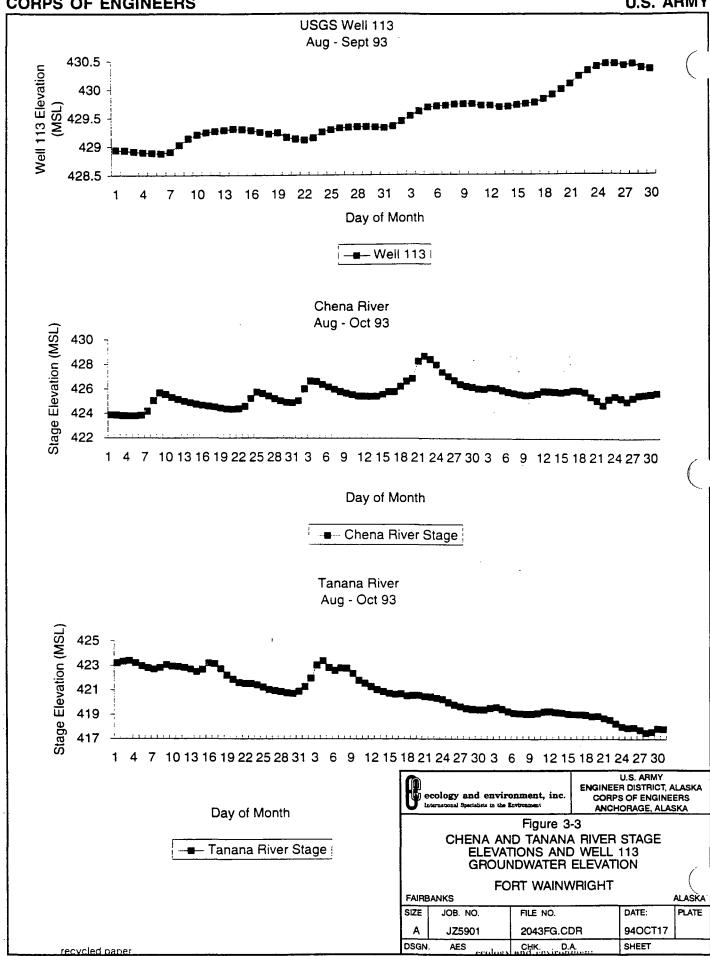
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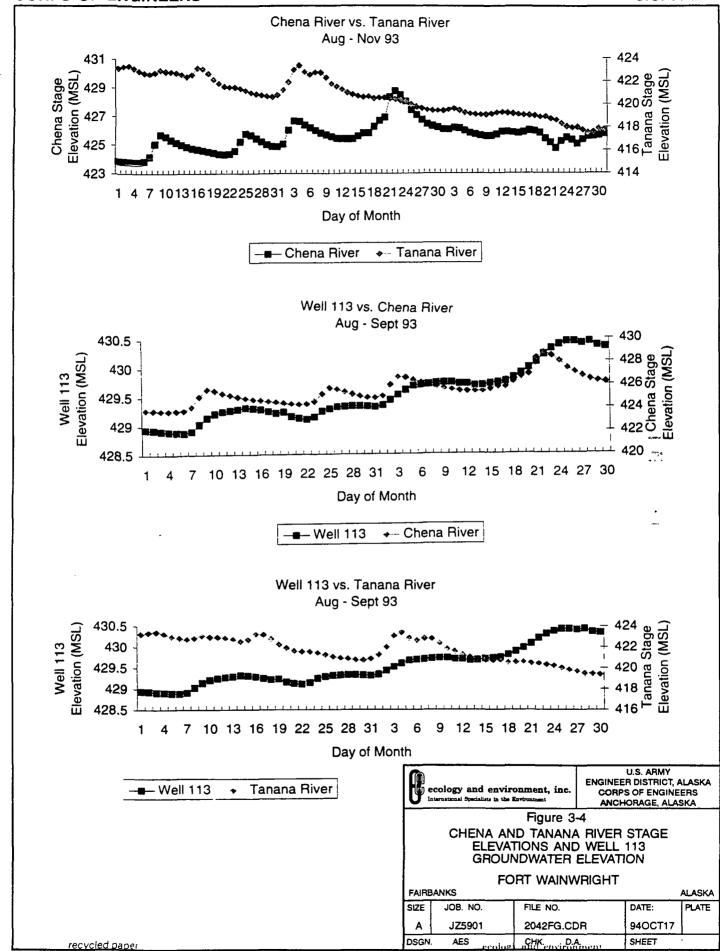
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4. QUALITY ASSURANCE/QUALITY CONTROL

This section describes the Fort Wainwright OU-4 RI analytical program, including program objectives, procedures, and QA review. The analytical data produced were used to support decisions regarding contamination at the OU-4 source areas; identify potential requirements for remedial action based on risks and ARARs; and provide information to assist in developing remedial engineering options. This section provides an evaluation of the laboratory QC analyses to determine the usability of the sample results. Data review (QA) provides the decision-maker with documentation and assurance that errors and uncertainty in data are within acceptable limits used to establish adequate performance of laboratories conducting the environmental analyses required for this study. Data usability review determines the adequacy of the data on a project-, site-, sample-, and analyte-specific basis, as a function of the data quality objectives (DQOs) presented in Appendix B of the OU-4 Management Plan (E & E 1993a).

4.1 ANALYTICAL PROGRAM

Three types of analytical laboratories analyzed samples for this RI: a temporary, onsite field analytical laboratory (field laboratory) established solely to support this project; a fixed, off-site project laboratory (project laboratory); and a fixed, off-site QA laboratory (QA laboratory).

The field laboratory analyzed surface soil, subsurface soil, sediment, surface water, and groundwater samples for TRPH and VOCs. The VOC analytes included benzene, toluene, ethylbenzene, meta-xylene (m-xylene), para-xylene (p-xylene), and ortho-xylene (o-

xylene), tetrachloroethene (PCE), trichloroethene (TCE), 1,1-dichloroethene, trans-1,2-dichloroethene, 1,1-dichloroethane, 1,1,2-trichloroethane, and 1,1,2,2-tetrachloroethane.

The project laboratories analyzed surface soil, subsurface soil, sediment, surface water, and groundwater samples. Individual samples were analyzed for various analytes as required in the Management Plan, including: VOCs; BNAs; pesticides/PCBs; TRPH; chlorinated herbicides; volatile petroleum hydrocarbons as GRO; extractable petroleum hydrocarbons as DRO; extractable petroleum hydrocarbons as fuel ID; polychlorinated dibenzo-p-dioxins/polychlorinated dibenzofurans; nitroamines and nitroaromatics; organophosphorus pesticides; total and dissolved metal; alkalinity; biological oxygen demand; bromide; chloride; fluoride; nitrate-nitrogen (N); nitrite-N; nitrate/nitrite as N; orthophosphate; silica; sulfate; TOC; TDS; and total phosphorus. The QA laboratory program is described in Section 4.1.2. A summary of the laboratory methods used is provided in Table 4-1.

4.1.1 Objectives

The main objectives of the field laboratory included:

- Providing analytical data in a cost-effective and timely manner to guide ongoing work in the field;
- Increasing the spatial coverage of the site; and
- Optimizing the selection of samples for project laboratory analyses.

The field laboratory guided field decisions; however, the RI extent of contamination was determined by project laboratory results.

The main objectives of the project laboratories included:

- Providing EPA Level III analytical data for site characterization and regulatory decision-making;
- Confirming results obtained in the field laboratory; and
- Generating data for risk assessment, geotechnical evaluation, engineering evaluation, and potential remediation options.

Field laboratory data were not used to delineate the extent or degree of contamination, nor were they used in the risk assessment. As part of the Corps' data validation program, a subset (i.e., 10% selected as splits and replicates) of project samples was submitted to the QA laboratory, designated by the Corps, for sample analyses. North Pacific Division Materials Laboratory (NPDML) validated project laboratory and QA laboratory data, compared laboratory data pairs, and produced a CQAR that documents the data validation results. The CQAR was used with field QC reports to document the usability of data for various purposes in the RI.

4.1.2 Laboratory Procedures

Brief summaries of the field, project, and QA laboratory procedures and an overview of chain-of-custody, data analysis, and data reporting for each laboratory are presented below.

4.1.2.1 Field Analytical Laboratory Procedures

Sediment, surface soil, subsurface soil, and selected groundwater samples collected during the field investigation were submitted to the field laboratory for analysis. Soil and sediment samples were collected into two 4-ounce glass jars with Teflon-lined septa lids. Water samples were collected in three 40-mL glass vials with a Teflon-lined septa lid.

Groundwater samples requiring field laboratory analysis were assigned a six-digit sample number after collection. The first three digits identified the sample location area. The last three digits identified the consecutive sample number from that area.

Surface water and soil samples requiring field laboratory analysis were assigned an eight-digit sample number after collection, except for the GeoprobeTM soil samples, which were numbered using the groundwater sample identification format. The first two digits (FL) designate the field laboratory. The third and fourth digits were the sample matrix code; e.g., SB for subsurface soils and SW for surface water. The fifth through eighth digit identified the sample location area and the consecutive sample number from that area.

As field laboratory samples were collected, sample data were recorded on a chain-of-custody form, which was relinquished to the project chemist when the samples were hand-delivered to the field laboratory. The project chemist verified samples delivered; recorded the sample numbers in a bound field logbook, designated as the *sample log*; signed the chain-of-custody form; and stored the samples in a secured refrigerator set at 4°C. The temperature of the refrigerator was verified each morning and recorded in a field logbook, identified as the refrigerator log. The samples were stored for up to 14 days after collection in case re-

analysis was necessary. After 14 days, samples were disposed of with other investigation-derived material (e.g., drill cuttings and well development water).

4.1.2.2 Total Recoverable Petroleum Hydrocarbons—Method Summary

Samples were analyzed for TRPH using a modification of EPA Method 418.1. Samples were extracted with 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113). Sodium sulfate was added to soil and sediment samples to remove excess moisture. Silica gel was added to all extracts to remove nonaliphatic hydrocarbons. The sample extracts were analyzed with a Horiba OCMA-220 oil content analyzer (nondispersive infrared spectrophotometer). Most carbon-hydrogen bonds absorb infrared energy of wavelengths between 3.4 to 3.5 microns. Absorption of energy at this wavelength is the quantitative basis for identification of petroleum hydrocarbons.

4.1.2.3 Calibration Procedures

An initial three-point calibration was performed to establish instrument linearity before sample analysis. Standards were prepared in accordance with EPA, Methods for Chemical Analysis of Water and Waste, EPA-600/4-79-020, March 1983, Method 418.1. A single-point calibration check was performed before sample analyses, every 6 hours during sampling analyses, and at the conclusion of sample analyses. If the relative percent difference (RPD) between the instrument reading and the actual standard concentration was greater than 30%, a new initial calibration was conducted and the affected samples were re-analyzed. The sample results were calculated based on the instrument reading, the sample weight or sample volume, the final extract volume, and the dilution factor.

4.1.2.4 Quality Assurance/Quality Control

The field laboratory QA/QC program included analyses of blanks, duplicate samples (to verify precision), and matrix spike (MS) samples (to verify accuracy). Following every standard and highly contaminated sample analysis, a method blank was analyzed to ensure that the system was free of interferences. The detection limits for the instrument were $2.4 \mu g/L$ for water samples and 20 mg/kg for soil samples, although sample detection limits varied depending on the sample size and required dilutions. If the analytical results for these samples failed to meet the field laboratory QC limits, the samples were re-analyzed.

4.1.2.5 Documentation and Reporting

All sample weights, sample volumes, solvent volumes, dilution factors, and sample calculations were recorded in field logbooks. Sample results also were recorded on data reporting forms and provided to the project manager to help guide ongoing field activities. QA/QC data also were recorded on data reporting forms, which summarized daily and/or weekly QA/QC events.

4.1.2.6 Volatile Organic Compounds—Method Summary

Samples were analyzed for VOCs using a modification of EPA Method 8021. The VOCs were extracted using a Tekmar LSC2000 purge and trap sampler and analyzed by a Hewlett-Packard (HP) HP5890 gas chromatograph (GC) with a photoionization detector (PID) and electron capture detector (ECD) in series. Five mL of a water sample or approximately 5 grams of a soil or sediment sample with 5 mL of deionized water were placed into a sparging vessel. The sparging vessel was purged with ultrapure helium, and the organic compounds were absorbed onto a trap. The trap then was heated, and the VOCs were desorbed into the GC system for analysis. The GC column separated the organic compounds by size and polarity based on the temperature and helium flow rate. The two detectors were located at the end of the column. The PID was used to identify and quantitate aromatic compounds and double-bonded compounds. The ECD was used to detect and quantitate electron-rich compounds (chlorinated solvents). Data acquisition was by a personal computer loaded with HP Chemstation software, specifically designed for GC operations.

4.1.2.7 Calibration Procedures

An initial three-point calibration was performed to establish instrument linearity before sample analysis. The standards were prepared in the field at concentrations that bracketed the expected range of sample concentrations. Analyte identification was based on comparison to standard retention times. Analyte quantitation was based on the internal standard method. The Chemstation software calculated the calibration factor (CF) for each analyte at each calibration level. The mean CF and relative standard deviation (RSD) of the CF's value were calculated for each analyte. If the RSD was greater than 30%, then the system was recalibrated.

A single-point calibration check was performed before sample analyses, every 12 hours during sampling analyses, and at the conclusion of sample analyses. If the RPD between the calculated calibration check CFs and the mean initial CFs was greater than 30%, then the instrument was recalibrated with a new initial calibration curve. If the RPD value for the final calibration was greater than 50%, the instrument was recalibrated and the samples run previous to the standard were re-analyzed.

Each analyte result was calculated based on the instrument response (area) for the target analyte and internal standard, the calibration factors for the analyte and internal standard, the sample weight or sample volume, and the dilution factor.

4.1.2.8 Quality Assurance/Quality Control

The field laboratory QA/QC program included analyses of blanks, duplicate samples (to verify precision), and MS samples (to verify accuracy). Following every standard and high-concentration sample analysis, a method blank was analyzed to ensure that the system was free of interferences. The detection limits for the instrument were 5 to 10 μ g/L for water samples and 5 to 10 μ g/kg for sediment or soil samples. If the QA/QC analyses failed to meet the field laboratory QC limits, the affected samples were re-analyzed.

4.1.2.9 Documentation and Reporting

All sample weights, sample volumes, and dilution factors were recorded in field logbooks. The sample results were recorded on data reporting forms and provided to the project manager to help guide ongoing field activities. QA/QC data also were recorded on data reporting forms that summarized daily and/or weekly QA/QC events. The electronic data were stored on floppy disks, and a hard copy of the chromatograms was archived daily.

4.1.2.10 Project and Quality Assurance Laboratories Procedures

NPDML contracted three off-site commercial laboratories to perform the analyses for the OU-4 RI. NPDML assigned Applied Research and Development Laboratories (ARDL) as the project laboratory for the FTP samples; Columbia Analytical Services (CAS) as the project laboratory for the CSY samples; and National Environmental Testing laboratories (NET) as the project laboratory for the Landfill samples. NPDML performed all QA sample analyses.

NPDML validated the project laboratory data and compared them to the QA laboratory results. The CQAR for each source area includes the data validation; summaries of the blind field duplicate sample results; and summaries of the trip blanks, rinsate blanks, and field blanks. A comparison of the data from the project and QA laboratories is presented in the CQARs.

All samples submitted to project and QA laboratories were handled according to Corps Regulation No. ER-1110-1-263, and sample containers complied with applicable guidelines outlined by EPA (Corps 1990). Decontamination procedures outlined in the OU-4 Management Plan (E & E 1993) were strictly followed.

All laboratory sample preparation and analyses were performed according to methods described in *Test Methods for Evaluating Solid Wastes* (EPA 1986), *Methods for Chemical Analysis of Water and Waste* (EPA 1983), or methods specified by the State of Alaska or NPDML (see Table 4-1). QC limits were defined by the specific analytical method. All data were validated by NPDML and reviewed by E & E. Independent of the NPDML data validation, E & E validated 10% of the project laboratory data.

Triplicate samples, trip blanks, equipment rinsate samples, and MS/matrix spike duplicate (MSD) samples were collected and submitted to both off-site laboratories to ensure that the quality of the analytical results met RI DQOs and that the results represented the media and field and transport conditions.

4.2 DATA QUALITY ASSURANCE REVIEW (1993 DATA)

A QA review was performed on data from the field laboratory, project laboratory, QA laboratory, and the field team. The field and project laboratory review was based on the laboratory's ability to meet its QA/QC program limits. The field laboratory data were compared to the project laboratory data to confirm the field laboratory analytical results. The project laboratory results were compared to the QA laboratory results to confirm project laboratory data. The QA laboratory results were not used to determine the conditions of the site, but to assess the quality of the project laboratory. Other QC samples collected by the field team (e.g., blanks) were analyzed to evaluate potential cross-contamination of samples resulting from sample handling, sample collection, decontamination procedures, or sample shipment.

4.2.1 Field Laboratory Quality Assurance

The field laboratory analyzed 449 soil, sediment, surface water, and groundwater samples. Field analytical data either were judged acceptable or were rejected when minimum QC requirements were not met. Most field laboratory data were considered acceptable for their intended use. A review of the QC results for the field laboratory data can be found in Appendix I of Volume III.

4.2.1.1 Field Audit

The field laboratory underwent three QA field audits: a Corps QA audit, before the laboratory was allowed to analyze samples; an E & E internal audit, verifying all aspects of the OU-4 RI Management Plan (i.e., that laboratory procedures and health and safety were in place); and an EPA audit. No significant problems or issues were uncovered by the audits (see Appendix I, Volume III, for copies of the Corps and the E & E audit; E & E did not receive a written copy of the EPA audit). The laboratory responded to all comments.

4.2.1.2 Total Recoverable Petroleum Hydrocarbons

Two hundred ninety-six samples were sent to the field laboratory for TRPH analysis. An E & E chemist evaluated the data for precision, accuracy, representativeness, completeness, and comparability (PARCC). All field laboratory TRPH data were considered acceptable for their intended use.

4.2.1.3 Field Laboratory Quality Control Sample Results

Nine water and 18 soil samples were analyzed as laboratory duplicate samples. Fifteen soil and 11 water blind field duplicate samples were collected. The RPD value (precision) between the laboratory duplicate samples and blind field duplicate samples measure the ability of the field laboratory to duplicate sample procedures and analytical techniques. All RPD values were within the laboratory QC limits.

The MS sample percent recovery (accuracy) measures the ability of the laboratory to accurately prepare and analyze samples. The MS sample results were considered acceptable for their intended use.

4.2.1.4 Project Laboratory Confirmation

Of the 296 TRPH samples analyzed in the field laboratory, 85 samples also were analyzed by the project laboratory. The results of the two laboratories were compared, and the correlation coefficient was calculated. When the pair of highest results (i.e., the TRPH results from both laboratories were greater than 60,000 mg/kg) was excluded from the comparison, the correlation coefficient was 0.9967.

4.2.1.5 Volatile Organic Compounds

Three hundred twenty-five samples were sent to the field laboratory for VOC analyses. An E & E chemist evaluated the data for PARCC criteria. The field laboratory data met the goals established in the OU-4 Management Plan (E & E 1993).

4.2.1.6 Field Laboratory Quality Control Sample Results

The field laboratory was unable to differentiate between the solvent (water)/air peak and one analyte, 1,1-dichloroethene, in 66 of the analyses. The field laboratory met the OU-4 RI Management Plan DQO for completeness with a value of 98%.

Twelve water and 29 soil and sediment samples were analyzed as laboratory duplicate samples. Fourteen soil and five water samples were analyzed as blind field duplicate samples. Based on RPD (precision) results between the duplicate samples, the VOC sample results were considered acceptable for their intended use.

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Based on MS percent recovery (accuracy), except for six analytes (data points), all MS recoveries were considered acceptable for their intended use.

4.2.1.7 Project Laboratory Confirmation

Of the 325 VOC samples analyzed at the field laboratory, 154 samples were analyzed by the project laboratory. The results of the two laboratories were compared, and the correlation coefficient was calculated. When the pair of highest results (i.e., VOC results from both laboratories were greater than 15,000 μ g/kg) was excluded from the comparison, the correlation coefficient was 0.9675.

4.2.2 Project and Quality Assurance Laboratories

NPDML evaluated all analytical data generated by the off-site laboratories for PARCC parameters. Based on the laboratory QC limits, the CQAR or E & E's validation (see Appendix I, Volume III) considered some of the project laboratory data to be unusable, and these data were rejected. The original result and qualifier were left unchanged, and the R qualifier was added to the qualifier field to denote rejection of the data. Rejected data were not used for making decisions concerning OU-4.

Based on other laboratory QC outliers, the CQAR or E & E's validation considered some of the laboratory results as estimated. The data were qualified with a J qualifier, which indicates that the analyte was present and positively identified but the associated numerical value may not be consistent with the amount actually present in the sample. The data were considered in decision-making and were useful for many purposes.

Although some of the project laboratory data were rejected or considered estimates, the data meet overall project DQOs. The project and QA laboratory data confirm the presence and extent of contamination as determined by the field laboratory.

4.2.2.1 Field Quality Control Samples

NPDML evaluated all field QA sample data generated by the laboratories to assess the field sampling and decontamination procedures.

Field Duplicate Samples

To provide an indication of the consistency of the overall sampling and analytical scheme, field duplicate samples were collected for all matrices. These samples were collected as blind duplicate samples, so the field or project laboratory would not be able to determine which samples were duplicates.

Thirty-one project laboratory blind field duplicate samples were analyzed. Field duplicate sample results are summarized in tables in the CQAR for each source area. RPD values were calculated for data pairs when an analyte was present in the sample and field duplicate sample. RPD values for the field duplicate results indicate general agreement for all parameters. Eighty-six percent of the RPD values were within EPA QC limits for single laboratory precision analysis of replicate analysis.

Thirty-eight blind duplicate samples were analyzed for TRPH and VOCs. The RPD values were calculated for all data pairs when an analyte was present in both samples analyzed. A summary of the field duplicate samples can be found in the laboratory review (see Appendix I), except for two sample pairs, which exceeded the linear ranges of the field methods (highly contaminated samples). All analytes were within laboratory RPD QC limits.

Given the reasonable correlation between the blind field duplicate sample results, the sampling and analytical schemes represent consistent sample media conditions.

Field Blank Samples

Two types of field blank samples were collected during the OU-4 RI. A trip blank was collected for the VOC analysis to assess conditions during transportation. An equipment rinsate blank was collected to demonstrate that the sample collection equipment was cleaned and prepared properly before field use and that cleaning procedures between samples were sufficient to minimize cross-contamination.

Forty-three trip blanks were analyzed to assess possible VOC contamination. The following VOCs were detected in the trip blank samples: acetone; 2-butanone; chloroform; 1,4-dichlorobenzene; 1,2-dichloroethane; methylene chloride; tetrachloroethene; toluene; and total xylenes. The two reported detections of total xylenes were due to laboratory contamination. In numerous trip blanks, acetone, 2-butanone, and methylene chloride were detected at concentrations near their respective detection limits. Although these analytes were not detected in all their respective method blanks, they are common laboratory and field contaminants and their presence most likely reflects laboratory and field or transport conditions. Eighteen trip blanks were contaminated with chloroform and/or 1,2-dichloroethane. According to the CQAR, the source of contamination by these analytes was contaminated water used to prepare the trip blank (Appendix I). The presence of chloroform and 1,2-dichloroethane is consistent with the chlorination of water and the subsequent formation of chlorinated organic compounds. The two tetrachloroethene and six of the eight toluene results detected in the trip blanks also were considered a result of laboratory and/or field and transport conditions. The two 1,4-dichlorobenzene and toluene results (samples 93FTP156GW and 93FTP157GW) could be due to cross-contamination because the two compounds were detected at similar levels in the associated blanks (see the CQAR in Appendix I). Consequently, results associated with trip blanks contaminated with acetone;

2-butanone; chloroform; 1,2-dichloroethane; methylene chloride; tetrachloroethene; and total xylenes were determined to be the result of laboratory and sampling activities and do not represent actual site conditions. Analytes detected in samples at less than five times the levels measured in the corresponding trip blanks are included in data summaries but are not included in the evaluation of site conditions.

A summary of the trip blank results and impacted samples for these analytes is presented in Table 4-2.

Thirty-four equipment rinsate blanks were analyzed to assess possible cross-contamination for the samples collected. The rinsate blank samples were analyzed for the same parameters as the respective associated samples. The following organic compounds were detected in various rinsate blank samples: acetone; 2-butanone; chloroform; 2,4-dichlorophenoxy acetic acid (2,4-D); 1,2-dichloroethane; gasoline; tetrachloroethene; and toluene. The following inorganic compounds were detected in the various rinsate blank samples: barium, calcium, iron, lead, magnesium, selenium, sodium, TOC, and zinc. Values for analytes detected in samples at less than five times the levels measured in the corresponding trip or equipment blanks are included in data summaries but are not included in the evaluation of site conditions. A summary of the rinsate blank results and impacted samples for these analytes is presented in Table 4-3. The VOCs detected in the rinsate blanks were considered a result of laboratory and/or field and transport conditions. The 2,4-D result was highly suspect and is considered a result of laboratory contamination. The gasoline result was considered a laboratory artifact, since the split sample did not contain gasoline. Most of the inorganic results, except for calcium and potassium, were within five times the laboratory detection limit. The inorganic results, including potassium and calcium, were considered laboratory contamination. The same actions as those taken in evaluating data based on trip blank contamination were applied to the evaluation of samples with these rinsate blanks. All rinsate blank results were considered a result of laboratory and/or sampling activities and not representative of actual site conditions.

4.3 DATA QUALITY ASSURANCE REVIEW (1994 DATA)

QA objectives for the analytical data generated during the Phase II, New Landfill Wells, sampling event were monitored by evaluation of field and laboratory QC analyses. Completed data packages from ARDL, the project laboratory, were forwarded to NPDML

laboratory. NPDML was responsible for reviewing all project laboratory and QA data. NPDML's Chemical Quality Assurance Report (CQAR) is Appendix I, and analytical data results are Appendix I.

The results of the QA report are summarized below.

4.3.1 Field Triplicates

To provide an indication of overall field variability, field triplicates were collected and analyzed. Blind duplicate samples were submitted to the project laboratory, and the triplicate sample was submitted to the QA laboratory. Overall, the data sets agreed with the following exceptions:

- Project blind duplicate data and QA data of samples 94LF902GW, 94LF903GW, and 94LF904GW did not agree for the following VOCs: chloroform, 2-butanone (MEK), cis-1,2-dichloroethene, benzene, and toluene. The discrepancy in the data could not be resolved analytically because both laboratories exhibited acceptable internal QC data;
- In triplicate set 94LF902GW, 94LF903GW, and 94LF904GW diesel No. 2 was detected in the project laboratory fuel identification and quantitation data but not in the QA laboratory data. The project laboratory's fuel identification data were determined to be unacceptable because of the unacceptable internal QC and quantitation approach used. The QA laboratory data may be used for this analysis;
- Nitrate/nitrite as nitrogen data for rinsates and samples could not be compared because of unidentical methods and reporting limits used by the laboratories; and
- BOD data of triplicate sample 94LF902GW, 94LF903GW, and 94LF904GW could not be compared because the QA sample was not analyzed before the holding time expiration date.

These issues are discussed further in the CQAR in Appendix I.

4.3.2 Equipment Rinsates and Trip Blanks

Two equipment rinsate blanks and two trip blanks were collected during the new-well sampling activities at the Landfill. The rinsate blank was prepared by pumping distilled water through the Grundfos pump into the appropriate sample containers. Analytical results for the rinsate and trip blanks are in Table 3-1.

Chloroform was detected in one QA laboratory trip blank, and toluene was detected in the other QA laboratory trip blank. The presence of these compounds in the QA samples and trip blanks was attributed to contaminated deionized water used to prepare the trip blanks, cross-contamination during sample shipment and storage, or laboratory contamination. The project laboratory data, however, were not affected.

Carbon disulfide was detected in project laboratory rinsate 94LF900GW and QA laboratory rinsate 94LF901GW. The presence of carbon disulfide in the rinsates, but not in the associated samples, indicates contamination in the deionized water used for preparing the rinsate.

Bis(2-ethylhexyl)phthalate was detected in rinsates 94LF900GW, 94LF901GW, and 94LF907GW. The presence of this compound indicates that cross-contamination may have occurred during sampling or that the deionized water used to prepare the rinsate samples may have been contaminated. Sample results at concentrations below the quantitation limit (10 μ g/L) should be considered insignificant, and sample results below 30 μ g/L (five times the concentration found in the rinsate) should be viewed with caution. Di-n-butylphthalate also was detected at an estimated 1 μ g/L in rinsate 94LF907GW, but because it was detected at such a low level (the quantitation limit is 10 μ g/L), the detection of this analyte is considered insignificant.

TRPH was detected at 0.4 mg/L in rinsate 94LF900GW, indicating that some cross-contamination occurred during sampling. TRPH results for samples 94LF902GW and 94LF903GW were flagged *BJ*, indicating that TRPH was detected in the rinsate blanks and that corresponding values should be viewed with caution.

Calcium and magnesium were detected in the QA laboratory rinsate 94LF901GW but were not considered to be significant.

TOC was detected at 1.1 mg/L in project laboratory rinsate 94LF907GW, indicating possible cross-contamination during sampling. TOC values of associated samples were significantly higher than the level detected in the rinsate, and samples were not considered to be affected.

4.3.3 Data Quality Control

All analytical data collected during the Landfill new-well sampling activities were evaluated for precision, accuracy, and completeness. The numbers and types (e.g., blanks,

duplicates, and matrix spike samples) of internal QC checks and samples were determined by the laboratory and applicable methodology.

In general, the project and QA laboratory data are acceptable, except for the project laboratory's data of fuel identification and quantitation (FIQ), which were rejected based on unacceptable internal QC and unacceptable quantitation approach used. FIQ data may be used for QA sample 94LF904GW. BNA data for project laboratory sample 94LF906GW data also were rejected because of an error in sample preparation at the project laboratory.

The precision and accuracy of the data generally are acceptable. Three of 12 MS/MSD recoveries for aldrin and/or dieldrin were below EPA QC limits because of matrix effect. Although the data are acceptable, analytes similar to aldrin and dieldrin may not have been detected during sample analyses.

MS recoveries of calcium, magnesium, potassium, and sodium were not submitted, so the accuracy of these parameters could not be determined completely.

Precision of BNA data could not be evaluated because of a laboratory accident during sample extraction, and precision of some analyses could not be determined because of a lack of sample volume. FIQ precision was considered unacceptable.

Di-n-butylphthalate was detected at a level below the detection limit in the method blank. The di-n-butylphthalate data of sample 94LF905GW should be considered because of laboratory contamination.

The VOC and GRO data of sample 94LF902GW should be viewed with caution because all samples contained bubbles and were considered to be compromised before analysis.

4.4 DATA USABILITY

In addition to data validation of laboratory performance, a data usability review was completed for all OU-4 RI data. This review determined the adequacy of data on a project site-, sample-, and analyte-specific basis to:

- Describe or characterize sample or site conditions;
- Describe, characterize, or interpret conditions or activities impacting a sample or site; and
- Describe, characterize, or interpret the results of conditions or activities impacting a sample or site.

Data usability is a function of the DQOs outlined as RI objectives and the overall QA review of field and laboratory data. The qualification of analytical data does not necessarily preclude use of that data for decision-making.

The main goal of sample collection and analysis under the RI process was to determine the presence or absence of target analytes and, if present, to provide a reasonable estimate of concentration. Data that failed to meet minimum validation standards were rejected and annotated with an R qualifier in the CQAR (see Appendix I). These data neither are reported nor utilized beyond that point. However, data flagged J were reviewed further to identify specific reasons for flagging; this information was incorporated into a determination of usability.

Results of field QC (trip blanks and rinsates) also were incorporated into the determination of usability. Following are key data use limitations that were identified:

- Deletion (R flag) of specific results because of failure to achieve minimum analytical QC criteria;
- Annotation (*J* flag) of the quantitative accuracy of a small fraction of the data;
- Deletion of data believed to be the result of common field or laboratory contamination;
- Limitations on the qualitative accuracy of fuel ID of specific target analytes, but not the presence or absence of petroleum-related contaminants when contaminants were found; and
- Limitations on the qualitative accuracy of fuel ID data as compared to ADEC GRO and DRO concentrations.

In summary, despite the specific limitations listed above, overall PARCC parameters for field and project data were achieved for the intended uses of the OU-4 RI analytical data. Specific limitations on data use for fate and transport purposes are discussed in Sections 6 and 7.

4.5 DATA VALIDATION

4.5.1 Landfill

Analytical data were evaluated by the Corps. The Corps' CQAR is provided in Appendix I. A validation of 10% of the project laboratory data was performed by E & E

personnel. These evaluations identified several problems with the 1993 Landfill analytical data (Corps 1993). The herbicide 2,4-D was rejected in most samples because of a large interfering peak at the same retention time as 2,4-D. Because of the inadequacy of the analytical data, 2,4-D was not considered in surface water, subsurface soil or ash samples, and its status as a contaminant at the Landfill is unclear. However, 2,4-D was not detected above the sample quantitation limit in any of the samples that were not rejected, including surface soil, groundwater, and sediment, and, therefore, is not a COPC in Landfill soil.

Contamination of blank samples also was documented in the CQAR for the Landfill Source Area data (Corps 1993). Analytes that may reflect laboratory contamination or contaminated-deionized water include acetone; methylene chloride; 2-butanone; toluene; chloroform; and 1,2-dichloroethane (Corps 1993).

4.5.2 Coal Storage Yard

Problems were encountered with the analytical data derived from the 1993 field investigation of the CSY (Corps 1993a). Approximately one-half of the herbicides data were compromised, reflecting erratic surrogate and matrix spike recoveries. Most of the dioxin and furan data for the CSY were questionable because of elevated background reporting, laboratory artifacts, and cross-contamination. Trichlorofluoromethane data were questionable probably because of laboratory contamination; however, the concentrations detected in laboratory blanks were low compared to detected concentrations in environmental media. The antimony data were questionable because of low matrix spike recoveries (Corps 1993a).

Analytes that may reflect blank contamination in CSY samples include acetone, methylene chloride, toluene, tetrachloroethene, m&p-xylene, naphthalene, and di-n-butylph-thalate. Relatively high concentrations of lead and selenium at this source area may have resulted from laboratory artifacts. Iron and zinc were detected at low concentrations in the rinsate.

4.5.3 Fire Training Pits

The CQAR also documented several problems with the analytical data derived from the FTPs Source Area (Corps 1993b). Herbicide data were considered as estimated concentrations because of erratic matrix spike recoveries. Also, approximately one-half of the sample coolers were received at elevated temperatures at the laboratory, potentially compromising the VOC data.

Blank contamination in samples from the FTPs Source Area because of laboratory contamination was indicated for acetone; 2-butanone; bis(2-ethylhexyl)phthalate; and 2,4-D. Trip and field blank contamination was indicated for toluene and 1,4-dichlorobenzene. Blank contamination, possibly reflecting incomplete decontamination in the field, was indicated for iron and sodium. Blank contamination resulting from contaminated deionized water used for trip blank samples was indicated for acetone; 1,2-dichloroethane; 2-butanone; chloroform; methylene chloride; and toluene (Corps 1993b).

Table 4-1

SUMMARY OF ANALYTICAL METHODS FORT WAINWRIGHT AUGUST THROUGH OCTOBER 1994 OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Parameter	Method	Laboratory
Total recoverable petroleum hydrocarbons	MCAWW Method 418.1 SW-846 Method 9071	Field/project laboratory
BTEX and chlorinated solvents ^a	Modified SW-846 Method 8021	Field laboratory
Volatile organic compounds	SW-846 Method 8260 and EPA Method 524.2	Project laboratory
Semivolatile organic compounds	SW-846 Method 8270	Project laboratory
Chlorinated pesticides/polychlorinated biphenyls	SW-846 Method 8080	Project laboratory
Chlorinated herbicides	SW-846 Method 8150	Project laboratory
Organophosphorus pesticides	SW-846 Method 8140	Project laboratory
Gasoline-range organics	ADEC Modified SW-846 Method 8015	Project laboratory
Diesel-range organics	ADEC Modified SW-846 Method 8100	Project laboratory
Fuel identification	NPDML Modified SW-846 Method 8015	Project laboratory
Nitroamines and nitroaromatics	SW-846 Method 8330	Project laboratory
Dioxins/furans	SW-846 Method 8290	Project laboratory
Total and dissolved metals ^b	SW-846 Methods 6000 and 7000	Project laboratory
Alkalinity	MCAWW Method 310.1	Project laboratory
Biological oxygen demand	MCAWW Method 405.1	Project laboratory
Bromine	MCAWW Method 320.1	Project laboratory
Chloride	MCAWW Method 325.1	Project laboratory
Fluoride	MCAWW Method 340.0	Project laboratory
Nitrate-N	MCAWW Method 353.1	Project laboratory
Nitrite-N	MCAWW Method 354.1	Project laboratory
Nitrate/nitrite as N	MCAWW Method 353.1	Project laboratory
Orthophosphate	MCAWW Method 365.2	Project laboratory
Silica	MCAWW Method 370.1	Project laboratory
Sulfate	MCAWW Method 377.1	Project laboratory
Total organic carbon	MCAWW Method 415.1	Project laboratory
Total dissolved solids	MCAWW Method 160.1	Project laboratory
Total phosphorus	MCAWW Method 365.2	Project laboratory

Key at end of table.

Table 4-1 (Cont.) Page 2 of 2

a Includes benzene; toluene; ethylbenzene; meta-xylene; para-xylene; ortho-xylene; tetrachloroethene; trichloroethene; 1,1-dichloroethene; 1,1-dichloroethane; 1,1-dichloroethane; 1,1,2-trichloroethane; and 1,1,2,2-tetrachloroethane.

b Includes aluminum, antimony, arsenic, barium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silicon, silver, thallium, and zinc.

Key:

ADEC = Alaska Department of Environmental Conservation.

BTEX = Benzene, toluene, ethylbenzene, and total xylenes.

EPA = United States Environmental Protection Agency.

MCAWW = EPA, Methods for the Chemical Analysis of Water and Waste, 600/4-79-020, March 1983.

N = Nitrogen.

NPDML = North Pacific Division Materials Laboratory.

SW-846 = EPA, Test Methods for the Evaluating Solid Waste, SW-846, November 1990.

Table 4-2

PROJECT LABORATORY TRIP BLANK SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Trip Blank	Date Collected	Associated Sample Numbers	Detected Analytes ^a	Concentr (μg/L	
Coal Storage Ya	rd				
93CSY010TBK	9-01-93	006SB, 007SB, 008SB	ND	N/A	
93CSY015TBK	9-07-93	009SB, 010SB, 011SB, 012SB, 013SB	Toluene Tetrachloroethene m&p-Xylenes	1 1 2	J J J,B
93CSY021TBK	9-07-93	016SS, 017SS, 018SS, 019SS, 020SS	Toluene Tetrachloroethene m&p-Xylenes	1.0 1.0 2.0	J J J,B
93CSY027TBK	9-07-93	022SB, 023SB, 025SB, 026SB	ND	N/A	
93CSY043TBK	9-10-93	028SS, 029SS, 030SS	Toluene Tetrachloroethene m&p-Xylene	2.0 1.0 3.0	J J J,B
93CSY047TBK	9-10-93	032SB, 033SB, 034SB	Bromomethane	3	J,B
93CSY045TBK	9-09-93	036SB, 037SB, 039SB, 040SB, 041SB, 042SB	ND	N/A	
93CSY056TBK	9-10-93	048SB, 049SB, 050SB, 051SB, 053SB, 054SB	ND	N/A	
93CSY061TBK	9-11-93	057SB, 058SB, 059SB	ND	N/A	
93CSY069TBK	9-15-93	061SD, 062SD, 066SW, 067SW	Acetone	11	J,B
93CSY071TBK	10-01-93	063SD, 064SD, 065SD	ND	N/A	
93CSY076TBK	9-20-93	070SD, 071SD, 072SD, 073SD, 074SD, 075SD	Methylene Chloride	8	
93CSY095GW	10-13-93	090GW, 091GW, 092GW, 093GW	Chloroform	2	J
Fire Training Pi	ts				
93FTP008TBK	9-01-93	001SB, 002SB, 003SB, 004SB 005SB, 006SB	Acetone 1,2-Dichloroethane	9 1.1	В
93FTP018TBK	9-02-93	009SB, 010SB, 011SB, 012SB, 013SB, 014SB, 015SB, 016SB	Acetone 2-Butanone	11 2	В
93FTP034TBK	9-13-93	019SB, 020SB, 021SS, 022SS, 023SS, 024SS, 025SS, 026SS, 027SS, 028SS, 029SS, 030SS, 031SS	Acetone 1,2-Dichloroethane 2-Butanone	13 0.6 3	В
93FTP049TBK	9-14-93	035SB, 036SB, 037SB, 039SB, 040SS, 041SS, 042SS, 043SS, 044SS, 045SS, 046SS, 047SS, 048SS	Acetone 1,2-Dichloroethane	14 0.7	В
93FTP065TBK	9-15-93	050SS, 051SS, 052SS, 053SS, 054SS, 055SS, 056SS, 057SS, 058SS, 059SS, 060SS, 061SS, 062SS, 063SS, 064SS	Acetone	13	В
93FTP078TBK	9-16-93	066SS, 067SS, 068SS, 069SB, 070SB, 071SS, 073SS, 074SS, 075SS, 076SS, 077SS	Acetone	12	В
93FTP086TBK	9-17-93	079SB, 080SB, 081SB, 082SB, 083SB, 084SS	Acetone	9	В

Key at end of table.

Table 4-2

PROJECT LABORATORY TRIP BLANK SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Trip Blank	Date Collected	Associated Sample Numbers	Detected Analytes ^a	Concentration (μg/L)
93FTP095TBK	9-18-93	087SS, 088SB, 089SB, 090SS, 091SS, 092SB, 093SB	Acetone	12 B
93FTP100 TBK	9-25-93	001SD, 002SD, 003SD, 010SD, 015SD	Acetone Methylene Chloride	13 B 1 B
93FTP101TBK	9-20-93	096SB, 097SB	Acetone	9 B
93FTP103TBK	9-21-93	098SB, 099SB, 104SS, 105SS, 106SB	Acetone	11
93FTP116TBK	9-22-93	108SB, 109SS, 110SS, 111SS, 112SS, 113SS	Acetone	13 B
93FTP117TBK	9-23-93	004SD, 005SD, 017SD	Acetone	10 B
93FTP121TBK	9-28-93	118SS, 119SS, 120SS	Acetone 1,4-Dichlorobenzene	9 B 0.5
93FTP129TBK	9-30-93	124SB, 125SB, 126SS, 127SB, 128SB	Acetone Methylene Chloride Chloroform	3 B 2 2.3
93FTP138TBK	10-01-93	131SB, 132SB, 133SS, 134SB	Acetone Methylene Chloride Chloroform 1,4-Dichlorobenzene	4 B 1 1.4 0.5
93FTP140GW	10-06-93	139GW	Acetone 1,2-Dichloroethene	10 0.8
93FTP147GW 93FTP148GW	10-07-93 10-07-93	141GW, 142GW, 143GW, 144GW, 145GW, 146GW	1,2-Dichloroethane Methylene Chloride Chloroform	0.8 3 1.7
93FTP156G W	10-10-93	149GW, 150GW, 151GW, 152GW, 153GW, 154GW, 155GW	1,2-Dichloroethane Methylene Chloride Chloroform Toluene 1,4-Dichlorobenzene	1.9 7 5.8 1.6 1.4
93FTP157G W	10-10-93	149GW, 150GW, 151GW, 152GW, 153GW, 154GW, 155GW	Acetone 1,2-Dichloroethane Chloroform Toluene 1,4-Dichlorobenzene	3.4 3.3 0.5 1.1 0.9
93FTP160T BK	10-18-93	158SS, 159SS	Acetone Methylene Chloride Chloroform	22 3 0.5
93FTP999 TBK	9-27-93	011SD, 012SD, 013SD, 014SD	Acetone 2-Butanone	11 B 2
Landfill Area				
93LF001TBK	9-14-93	002SS, 003SS, 004SS, 005SS, 006SS	ND	N/A
93LF002TBK	9-15-93	013SS, 014SS, 015SS, 016SS, 017SS, 018SS, 019SS, 020SS	Acetone Methylene Chloride	5.2 1.1 B
93LF003TBK	9-16-93	021SS, 022SS, 023SS, 024SS, 025SS, 026SS, 027SS	Acetone	3.5
93LF005TBK	9-15-93	001SD, 002SD, 003SD	ND	N/A
93LF006TBK	9-28-93	004SD, 005SD, 006SD, 002SW	ND	N/A

Key at end of table.

Table 4-2

PROJECT LABORATORY TRIP BLANK SUMMARY **OPERABLE UNIT 4** FORT WAINWRIGHT, ALASKA

Trip Blank	Date Collected	Associated Sample Numbers	Detected Analytes ^a	Concentration (μg/L)
93LF007TBK	9-23-93	002SB	ND	N/A
93LF008TBK	9-23-93	003SB, 004SB	ND	N/A
93LF010TBK	9-28-93	007SB, 008SB, 009SB	ND	N/A
93LF011TBK	9-29-93	013SS, 014SS, 015SS	ND	N/A
93LF013TBK	9-28-93	010SB	Methylene Chloride	1.3 B
93LF310TBK	9-29-93	302SD, 303SD, 304SD, 305SD, 306SD, 307SD, 308SW	Acetone Methylene Chloride	2.7 1.3
93LF311TBK	9-30-93	301SD, 300SW	ND	N/A
93LF312FBK	9-29-93	302SD, 303SD, 304SD, 305SD, 306SD, 307SD, 308SW	Methylene Chloride Chloroform	3.0 B 1.7
93LF320TBK	10-01-93	314SW, 318SW, 319SD	ND	N/A
93LF324TBK	9-30-93	321SS, 322SS, 323SS	ND	N/A
93LF325TBK	10-01-93	313SW, 316SD, 317SD	ND	N/A
93LF329FBK	10-01-93	327SW, 328SD, 330SD, 331SW, 332SD, 333SW, 334SD, 335SW, 336SD, 337SD	Methylene Chloride	1.6 B
93LF344TBK	10-03-93	338SW, 339SD, 341SD	Methylene Chloride Chloroform	2.4 B 2.3
93LF421TBK	10-21-93	418SB, 419SB	Acetone Methylene Chloride	10 2.8 B
93LF425TBK	10-25-93	422SB, 423SB	Acetone Methylene Chloride Toluene	12 2.9 B 1.6

Common laboratory contaminant analytes and analytes detected in the laboratory blanks were not included in this

Key:

B = Blank contamination.

ID = Identification.

J = Estimate quantity.

μg/L = Micrograms per liter.

ND = No analytes detected.

N/A = Not applicable.

Table 4-3

PROJECT LABORATORY RINSATE SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Rinsate Blank ID	Date Collected	Associated Sample Numbers	Detected Analyte(s) ^a	Concentration (µg/L)
Coal Storage Ya	rd			
93CSY009RNS	9-1-93	006SB, 007SB, 008SB	ND	NA
93CSY014RNS	9-4-93	009SB, 010SB, 012SB, 013SB	Toluene Tetrachloroethene Iron Lead	2.0 J 1.0 J 120 5.9
93CSY024RNS	9-7-93	022SB, 023SB, 025SB, 026SB	ND	ND
93CSY035RNS	9-8-93	032SB, 033SB, 034SB	ND	NA
93CSY038RNS	9-9-93	036SB, 037SB, 039SB, 040SB, 041SB, 042SB	ND	NA
93CSY052RNS	9-10-93	048SB, 049SB, 050SB, 051SB, 053SB, 054SB	ND	NA
93CSY060RNS	9-11-93	057SB, 058SB, 059SB	Chloroform Lead Selenium Zinc TOC	4.0 J 8.3 7.6 8.6 2.5
93CSY068RNS	9-15-93	061SD, 062SD, 066SW, 067SW	ND	NA
93CSY070RNS	10-1-93	063SD, 064SD, 065SD	ND	NA
93CSY094GW	10-13-93	090GW, 091GW, 092GW, 093GW	Chloroform	0.5 J
Fire Training Pi	s			
93FTP007RNS	9-1-93	001SB, 002SB, 003SB, 004SB, 005SB, 006SB	ND	NA
93FTP017RNS	9-2-93	009SB, 010SB, 011SB, 012SB, 013SB, 014SB, 015SB, 016SB	Calcium Iron Magnesium Sodium Zinc	89 183 22 450 45
93FTP032RNS	9-3-93	019SB, 020SB, 021SS, 022SS, 023SS, 024SS, 025SS, 026SS, 027SS, 028SS, 029SS, 030SS, 031SS	Magnesium Sodium	13 240
93FTP038RNS	9-14-93	035SB, 036SB, 037SB, 039SB, 040SS, 041SS, 042SS, 043SS, 044SS, 045SS, 046SS, 047SS, 048SS	1,2-dichloroethane Iron Magnesium Sodium Zinc	0.6 30 16 254 16

Key at end of table.

Table 4-3

PROJECT LABORATORY RINSATE SUMMARY OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Rinsate Blank ID	Date Collected	Associated Sample Numbers	Detected Analyte(s) ^a	Concentration (μg/L)
93FTP072RNS	9-16-93	066SS, 067SS, 068SS, 069SB, 070SB, 071SS, 073SS, 074SS, 075SS, 076SS, 077SS	ND	NA
93FTP085RNS	9-17-93	079SB, 080SB, 081SB, 082SB, 083SB, 084SS	Magnesium Potassium Sodium Zinc	17 10,000 2590 37
93FTP094RNS	9-18-93	087SS, 088SB, 089SB, 090SS, 091SS, 092SB, 093SB	ND	NA
93FTP100RNS	9-20-93	096SB, 097SB	ND	NA
93FTP102RNS	9-21-93	098SB, 099SB, 104SS, 105SS, 106SB	ND	NA
93FTP114RNS	9-22-93	108SB, 109SS, 110SS, 111SS, 112SS, 113SS	ND	NA
93FTP127RNS	9-30-93	124SB, 125SB, 126SS, 127SB, 128SB	2,4-D Barium Iron Magnesium Sodium Zinc	5.1 13 36 16 660 14
93FTP136RNS	10-1-93	131SB, 132SB, 133SS, 134SB	Iron Magnesium Sodium	91 15 697
Landfill Area				
93LF001RNS	9-14-93	001SD, 002SD, 003SD	ND	NA
93LF002RNS	9-15-93	002SW, 004SD, 005SD, 006SD	ND	NA
93LF003RNS	9-16-93	00SB	ND	NA
93LF004RNS	9-24-93	004SB	ND	NA
93LF005RNS	9-24-93	005SB, 006SB	ND	NA
93LF006RNS	9-28-93	007SB, 008SB, 009SB	ND	NA
93LF007RNS	9-28-93	010SB	ND	NA
93LF309RNS	9-29-93	300SW, 301SD	ND	NA
93LF403RNS	10-8-93	369GW, 371GW, 402SS, 404SB, 405GW, 406GW	Gasoline	130
93LF416RNS	10-13-93	413SS, 414SB, 415SB, 417SB	Chloroform	1.7
93LF420RNS	10-21-93	418SB, 419SB	ND	NA
93LF424RNS	10-25-93	422SB, 423SB, 424SB	ND	NA

Key at end of table.

^a Common laboratory contaminants and analytes detected in the laboratory blanks were not included in this table.

Key:

J = Estimated quantity.

ID = Identification.

NA = Not applicable.

ND = No analytes detected.

 μ g/L = Micrograms per liter.

TOC = Total organic compounds.

5. LANDFILL SOURCE AREA

The following section summarizes the data collected from the Landfill Source Area, which includes the Former Trench Area south of River Road. References to the Landfill itself include only the area of Landfill activities that is approximated by the 10-foot contour depicted on Landfill figures (see Figure 1-2). Investigations and sample collection were limited to areas surrounding the Landfill refuse collection areas, except for surface soil samples and noninvasive geophysical techniques. Because of the unknown contents of the Landfill and potential for explosive ordnance, drilling was not conducted through the Landfill.

Data and discussions regarding characterization of the Landfill Source Area, including data obtained from previous investigations, are presented in four sections. The first section discusses the physical characteristics of the Landfill Source Area, as defined by lithologic descriptions of surface and subsurface soil and geophysical data, and characterizes groundwater occurrence and hydraulic parameters. The second section discusses the nature of contamination determined from analytical work and is followed by a section that describes the extent of contamination. The final section discusses the chemical-specific ARARs appropriate for the Landfill Source Area.

5.1 PHYSICAL CHARACTERISTICS

A summary of surface and subsurface soil, sediment, and groundwater samples collected from the Landfill Source Area during the 1993 and 1994 field activities is presented in Tables 2-1 through 2-4. As part of the RI, a combination of existing monitoring wells and the new monitoring wells (1993 and 1994) and soil borings were used for characterization, as indicated in Table 5-1. Each medium's physical characteristics for 1993 and 1994 RI activities are discussed below, along with the geophysical work completed at the Landfill.

5.1.1 Surface Soil and Sediment

Thirty-five surface soil samples were collected for chemical analyses, with four samples selected for physical parameter testing (grain size and moisture content) from five distinct areas (see Figure 5-1). The sampled areas included the Ski Lodge Area (SS-2) north of the Landfill, the possible Trench Area (SS-23 and SS-24) northwest of the Landfill, along a drainage culvert (SS-10 and SS-15) southwest of the Landfill, a stressed vegetative area (SS-3 and SS-4) south of the Landfill, and locations along a drainage culvert (SS-16 and SS-21) southeast of the Landfill. Nine ash samples also were collected; four samples were analyzed for physical parameters.

Results of the physical analysis of surface soil indicate that soil around the Landfill varies somewhat, but is generally classified as fine-grained soils. Figure 5-1 presents the surface geology of the Landfill based on previously published geologic data and as interpreted from surface soil sample locations, boring and monitoring well locations. Classification of soil by sieve analysis (ASTM-D 2487; see Table 5-2) shows that there are poorly graded sand (SP) south of the Landfill, inorganic silt (ML) in the east drainage culvert, and organic silt (OL) and silty sand (SM) west of the Landfill. The sieved ash samples were observed as a fine gray granular material, and all were classified as silty sand (SM), with one sample high in organic matter.

Sixteen sediment samples were collected at the Landfill. SD-1 through SD-4 were collected in pond water north of the Landfill Source Area. SD-5 and SD-6 were collected beneath pond water at the base of Birch Hill near the Ski Lodge. SD-7 and SD-8 were collected beneath pond water south of the Landfill Source Area. SD-9 through SD-11 were collected along a drainage depression from the southwest portion of the Landfill Source Area to the Chena River. SD-12, SD-13, and SD-14 were collected from the drainage culvert southeast of the Landfill Source Area, where the culvert drains into the Chena River. To provide background concentrations, SD-15 and SD-16 were collected at the base of Birch Hill near the Ski Lodge. The drainages where SD-15 and SD-16 were collected did not contain water and do not exhibit erosion features that would suggest periodic active drainage flows of water. The sediment samples were not analyzed for physical parameters but were classified by visual inspection as fine-grained materials (silt and/or silty sand) representative of low-energy transport conditions.

5.1.2 Subsurface Soil

Fifteen boreholes were drilled around the Landfill as part of the OU-4 field activities; 10 of the boreholes were completed as monitoring wells. The remaining five borings were used to provide analytical and lithological characterization. No boreholes were drilled into the Landfill itself because of the potential presence of ordnance. In cases where a soil boring was immediately adjacent to a planned monitoring well, soil samples were collected from the soil boring and not the monitoring well. Monitoring wells planned to characterize the groundwater quality were referred to as *shallow monitoring wells*, and monitoring wells planned to characterize deeper aquifer groundwater quality are referred to as *deep monitoring wells*. Additional ground truth borings and deep wells were completed at the Corps' and CRREL's direction following completion of RI activities during the 1994 field season. Data obtained from a limited amount of boring logs provided by CRREL are incorporated into the final RI. Additionally, the 1995 CRREL report, *Geological and Geophysical Investigations of the Hydrology of the OU-4 Landfill*, was incorporated where possible (CRREL 1995).

The boreholes drilled for shallow monitoring wells were advanced until groundwater was encountered at an average depth of less than 15 feet BGS. Boreholes drilled for deep monitoring wells were advanced to 200 feet BGS if formation permitted, as prescribed by the Management Plan (E & E 1993). Generally, boreholes were drilled 100 feet to 150 feet; however, in two cases (AP-6131 and AP-6177), boreholes were drilled to 200 feet. As indicated in the MP, the depth of 200 feet was selected to assure that a subpermafrost well could be installed.

...

Subsurface soil encountered from the boreholes at the Landfill Source Area consists mostly of unconsolidated silt, sand, and gravel of alluvial origin on the south, east, and west areas of the Landfill from ground surface to the maximum depth drilled (i.e., 200 feet BGS) as determined previously by the Corps. The north area of the Landfill is also underlain by silt, sand, and gravel to a degree, but deposits, described as *loess* (wind-deposited, fine-grained silt), in the Tank Farm area and northward on Birch Hill, along with Birch Creek schist, are found at depth.

Permafrost was encountered during the drilling operations in subsurface soil at the Landfill Source Area during the 1993 and 1994 field activities and during previous investigations, and is generally discontinuous in areal and vertical distribution. Figures 5-2 through 5-5 are schematic cross sections, through the Landfill, which detail the subsurface encoun-

tered during the drilling. The permafrost encountered was typically of low ice content within silt and sand units, although several instances of ground ice and ice lenses were present within the sand and gravel intervals, and thick sections of permafrost were found to exist from near ground surface through total depth to the bedrock interface. No boreholes were drilled within the active Landfill Source Area. A discussion of interpretations of what is beneath the Landfill Source Area is discussed below and in Section 5.1.3.

Figure 5-1 presents all boreholes completed to date at the Landfill Source Area. Schematic geologic cross sections of the Landfill were constructed across transects depicted in Figure 5-1. The cross sections incorporate data from all soil borings and monitoring wells currently installed at the Landfill, including historical borehole data from previous Landfill investigations. The cross sections also incorporate several of CRREL's ground-truth borings and the monitoring well information provided, but do not include any of the 1994 borings in which new deep monitoring wells have been installed in the Landfill Source Area.

Cross section A-A' depicts a north-south transect schematic of the Landfill's west edge (see Figure 5-2). Subsurface soil consists of surface deposits of a 5- to 25-foot-thick layer of silt occasionally cut by 10- to 20-foot-thick deposits of sandy silt and silty sand with occasional gravel. The silt is underlain by poorly graded gravel, sandy gravel, and gravelly sand with discontinuous lenses of silty sand, sand, and gravelly sand. The gravelly unit on the north part of the transect is approximately 50-feet-thick; however, the base of the gravel deposit is not defined by boreholes south of River Road in the south section of the cross section. A silty sand and sandy unit underlies the gravel unit. The silty sand and sandy unit is 80- to 90-feet-thick. Examination of data from borehole AP-6349 and data provided by CRREL (1995) indicates that the Birch Hill schist underlies the gravel and sand deposits. The data also indicate that the surface of the Birch Hill schist increases in depth from 120 feet BGS to greater than 200 feet BGS south of River Road along the length of the cross section. The gravel units and the units underlying the gravel apparently thicken to the south. Permafrost is present from Birch Hill south to the drainage area, where no permafrost was encountered in the borings completed within it. Permafrost again was encountered near the gravel pits south of the Landfill in monitoring well AP-5595 and near the south end of the transect. Permafrost was not encountered in borehole AP-6134, possibly indicating another preferential transport pathway. The areas where permafrost was not encountered also were

identified in the geophysical surveys completed at the Landfill and are discussed in Section 5.1.3.

Cross section B-B' depicts an east-west transect schematic across the Landfill (see Figure 5-3). Subsurface soil consists mainly of silt and silty sand from the surface of approximately 5 to 10 feet BGS, except for gravelly sand and silty sand lenses, which are 10-to 40-feet-thick and appear to thicken to the east. These units are underlain, from 10 to approximately 60 or 70 feet BGS, by interlayered sand and gravel; poorly-graded gravel and sand with interlayered lenses of poorly-graded sand; and silty sand. Inferred from data provided by CRREL (1995), this unit is underlain by the Birch Hill schist at a depth of greater than 160 feet to 200 feet BGS along the cross section. Permafrost was encountered on the east and west side of the Landfill, with an especially thick layer of permafrost in the west end of the transect.

Cross section C-C' depicts a north-south transect schematic of the Landfill's east edge (see Figure 5-4). This cross section is similar to cross section A-A', consisting of an incongruous 0- to 5-foot layer of silt, sandy gravel, and gravelly sand deposits, with occasional surficial layers of peat and organic silt. These units are underlain by a continuous layer of silt, occasionally silty peat, and sand and silty sand from 5 to 20 feet BGS across the cross section. The silt is underlain by poorly graded gravel, sandy gravel, and gravelly sand with discontinuous deposits (lenses) of silty sand, and gravelly sand. The gravelly unit is deposited between 20 and 80 feet BGS and thins to the north. A silty sand and a sandy unit underlying the gravel unit was identified only by borehole AP-6177 at approximately 100 feet BGS. Permafrost was in borings completed in the north portion of the transect but was not found consistently in the south portion of the transect adjacent to the Chena River. This finding may indicate that the thermal effects of the river maintain a thaw zone beneath and to the north of the river. Birch Hill schist was encountered at approximately 150 feet BGS at well FWLF-1/110 (interpreted from borehole logs). This interpretation is supported by data provided by CRREL (1995). The data from the surrounding boreholes indicate that the surface of the Birch Hill schist slopes to the south, increasing in depth from 150 feet BGS to greater than 200 feet BGS along the cross section.

The 200-foot boring adjacent to the Chena River (AP-6177) originally was designed to provide shallow and deep groundwater quality and lithologic characteristics as a monitoring well, but no saturated zones were detected. No permafrost was identified or logged in

split-tube samples or air rotary cuttings, and sampled materials appeared dry. Well AP-6132 was drilled to approximately 25 feet BGS and was completed as a shallow monitoring well approximately 300 feet north of AP-6177. The lack of observable soil moisture in AP-6177 was an anomaly that may be attributed to permafrost of low ice content, not detected during the drilling operations. The high volumes of compressed air used during drilling may have sublimated the permafrost of low ice content before it could be detected as ice or meltwater in cuttings or samples. Water levels were attempted periodically while allowing the borehole to set over night, on the premise that low productive formation materials eventually would allow groundwater to enter the borehole. No groundwater was detected within the borehole, which subsequently was abandoned, and the construction of the monitoring well was relocated to the AP-6132 boring location.

Cross section D-D' depicts a north-south transect schematic of the far west edge of the Landfill and is completed with subsurface information provided by CRREL during ground-truth borings (see Figure 5-5). The subsurface geology is characterized by silt from the surface to approximately 10 feet BGS and is occasionally overlain by a thin layer of organic silt and peat. A thick unit of gravel with discontinuous lenses of poorly graded sand and silty sand underlies the silt, which thickens from 30 to 50 feet from east to west. Birch Hill schist, which underlies the gravel, was encountered at approximately 25 feet BGS at well AP-6435. Borehole data provided by CRREL (1995) from the surrounding boreholes indicates that the surface of the Birch Hill schist slopes to the south, increasing in depth from 25 feet BGS to greater than 170 feet BGS along the cross section. A poorly-graded sand with discontinuous lenses of silty sand, sand, and gravelly sand underlies the gravel for the remainder of the cross section. The boreholes do not define the thickness of this unit. Permafrost was present down to bedrock on the north part of the cross section and at a considerable depth and thickness in the middle of the transect (AP-6439 and AP-6436), but was not encountered in borings completed in the drainage area near Birch Hill or River Road. The lack of permafrost near River Road may be due to influences from the Chena River close to the south end of the cross section.

5.1.2.1 Geotechnical Sample Results

To provide information for a potential treatability and feasibility study, and for selecting remedial alternatives, physical parameter analyses were conducted on subsurface soil

collected from two soil borings (two depth ranges per selected soil boring). The physical parameter testing, conducted by the NPDML, included percent moisture, specific gravity, grain size, and Atterberg limits. These are standard engineering geotechnical parameters described in the ASTM D-2487 and TM5-818-2 methods (see Appendix F). Table 5-2 summarizes the soil sample classifications provided by the laboratory and field soil classifications recorded by the field geologists. No field soil classification was attempted on the ash samples collected at the Landfill, but laboratory classification described them as being silty and fine-grained.

5.1.3 Geophysical Survey Results

A detailed geophysical survey was performed for the Landfill Source Area to characterize the subsurface, particularly beneath the Landfill cap where drilling was not conducted, and to aid in developing the conceptual site model that could provide information about preferential pathways affecting contaminant transport. Geophysical techniques utilizing the EM-31, EM-34, EM-47, and GPR were used to establish a sounding signature of the permafrost, and to delineate the permafrost in the Landfill Source Area. Geophysical data were correlated with geologic boring and monitoring well lithologic logs to establish a conceptual site model of the underlying stratigraphy. The geophysical data were compared and conformed to this conceptual model, as much as possible, while maintaining both fundamental geophysical relationships and the ground-truth data provided in the borehole lithologic logs from 1993 and other previous field activities. The geophysical interpretation includes some of the boreholes drilled by CRREL during the 1993 and 1994 field season and utilizes additional information provided by CRREL in its 1995 report (CRREL 1995).

The geophysical and lithologic data support that permafrost exists at the Landfill but varies in thickness and depth. A thaw bulb, or more accurately a lack of permafrost, appears to exist beneath the Landfill. It is unknown whether this permafrost-free area beneath the Landfill is continuous to the bedrock. The geophysical data indicate that drainage pathways and underlying talik zones could be considered potential transport pathways for contaminants. Several talik zones and permafrost-free channels also were characterized during the extensive geophysical and ground-truth (i.e., soil borings) conducted by CRREL between the Tank Farm and the Landfill.

Several of the geophysical surveys were interpreted through the use of geophysical models in which data were fit to existing and newly completed boreholes and their observed and interpreted lithologies. The models also utilized the fact that gravel, silt, sand, and clay generally increase in an order of magnitude in resistivity when their temperatures are reduced from 5° C to -5° C. Specifically, the resistivity of Fairbanks silt and saturated sand and gravel were increased by an order of magnitude over the 5° C to -5° C temperature range from 10^2 to 10^3 ohm-m and from 10^3 to 10^4 ohm-m, respectively. These readings indicate fairly resistive units. Additionally, a representative graphite schist similar to the Birch Creek schist bedrock had a resistivity of 10 to 10^2 ohm-m (McNeil 1980).

5.1.3.1 EM-31

The EM-31 survey was completed by walking over the suspected trench areas and recording any deflections of the EM-31 meter needle. A drum or other buried metal object typically produces a deflection on the instrument based on size and relative depth from the instrument. This technique is effective for determining the areal extent of possible trenches and any associated buried debris.

The trenches northwest of the Landfill are approximately 20-feet-wide and 6-feet-deep, based on EM-31 instrument readings, and showed no indication of containing any buried ferrous material. A visual observation was made during the survey. Several drums are scattered between the northwest trench area and the Landfill periphery. The northwest part of the Landfill, particularly along the edge of the Landfill, comprises numerous 55-gallon drums. The difference in elevation from the top of the Landfill to the original ground surface is approximately 30 feet.

The trenches south of the Landfill also were investigated with the EM-31 instrument. The two main trench areas south of the Landfill are referred to as the *Middle Trench Area* (near the biocells) and the *South Trench Area* (see Figure 5-1).

The Middle Trench Area consists of approximately two trench-like expressions that trend nearly north-south (at approximately 330° azimuth) and that are approximately 25-feet-wide and 50-feet-long. The Middle Trench Area exhibited many meter deflections indicative of drums or metal debris. Several drums, crushed and partially buried, are exposed throughout the area, including beneath the road that runs directly south of River Road to the gravel

pit areas and on either side of the road. A discarded sign found in the area reads, "Caution: Covered Wet Garbage Trenches."

The South Trench Area consists of approximately two trenches that trend northeast-southwest (at approximately 50° to 60° azimuth) and that are approximately 15-feet-wide and 500-feet-long. Large holes exist at the southwest end of the trench and are approximately 15-feet-wide and 6-feet-deep. Another trench may exist at the northeast end of the trenches where instrument readings indicated metal debris or disturbed material trending north-south (approximately 330° azimuth) for 25-feet-long. Instrument readings in the South Trench Area did not indicate metal deflections equivalent to those expected from buried drums. Small deflections of the meter occurred in the western portion of the trenches and is an indication of small buried metal debris.

5.1.3.2 EM-34

EM-34 traverses at the Landfill Source Area are depicted in Figure 5-6. Anomalies that exhibited higher conductivity readings (i.e., greater than 30 mmhos/m) and extreme negative values (i.e., less than -5 mmhos/m; E & E 1991, 1993a; WCC 1989) were identified at the Landfill backfill and refuse area (active areas) and in the buried debris (i.e., drums and metal) at the northwest area. Areas with permafrost show anomalies that exhibited readings of between 0 to 5 mmhos/m, while anomalous areas with no permafrost exhibited readings of greater than 5 mmhos/m with increasing conductivity nearer the Chena River.

Figures 5-7 through 5-10 indicate that the areal extent of permafrost appears to be present discontinuously, surrounding much of the Landfill Source Area, but absent beneath the Landfill itself and south toward the Chena River. By interpreting the response of the different positions, an indication of the vertical and horizontal extent of permafrost and conductive features can be assessed.

EM-34 data also were utilized to develop three-dimensional block diagrams of the Landfill to help in determining the presence of thawed areas and permafrost zones. Figures 5-11 through 5-14 are three-dimensional extrapolations of the relative strength of the EM-34 reading with depth, and they represent the horizontal 20- and 40-meter and vertical 20- and 40-meter separations, respectively.

The horizontal 20-m EM-34 coil separation (see Figures 5-7 and 5-11) depicts a large anomaly associated with the numerous 55-gallon drums observed in the northwest corner of

the Landfill. The remaining figures show that permafrost is present immediately surrounding the Landfill (0 to 5 mmhos/m) but no distinctive anomalous features are present, except in the south of the Landfill. The anomaly south of the Landfill may be interpreted as a preferential pathway for transport, as it represents conductivity values greater than 10 mmhos/m. This interpretation is supported by geologic cross section B-B', which also shows the lack of permafrost in this area. The anomaly present in the southeast of the Landfill Source Area is not related to any data but is rather an artifact of the extent of the contouring algorithm.

The horizontal 40-m EM-34 coil separation (see Figures 5-8 and 5-12) depict the same anomaly associated with the numerous 55-gallon drums observed in the northwest corner of the Landfill as with the horizontal 20-m EM-34 coil separation, but the influence is not as strong at the interpreted 30-m depth. The numerous drums in the northwest corner of the Landfill present near the surface generate very large positive and negative values that contaminated the survey field of the instrument. This residual effect was echoed in the deeper depth soundings even though the drums are present in the near surface and not necessarily within the zone of penetration. A large negative anomaly is present in the southeast of the Landfill and is suspected to be related to the same preferential pathway interpreted from the horizontal 20-m data. A large anomaly, interpreted as a large potential pathway, is shown in the southwest corner of the Landfill, which is consistent with the lack of permafrost characterized in the geologic cross sections. In addition, a smaller pathway is present in the southwest portion of the Landfill. A fairly significant section of permafrost is indicated in the west edge of the Landfill and is consistent with the permafrost shown in the boreholes and cross sections.

The vertical 20-m EM-34 coil separation (see Figures 5-9 and 5-13) depicts the anomaly associated with the drums in the northwest corner of the Landfill. Permafrost appears to be indicated southwest of the Landfill near the gravel pits and monitoring wells AP-5595 and AP-5585. A potential contaminant migration pathway is in the southeast corner of the Landfill and is consistent with the horizontal 40-m, the borehole, and other geophysical data. A large, negative anomaly southeast of the Landfill may be due to interference associated with the fence and power lines along River Road. A comparison of the horizontal 40-m data and the vertical 20-m data, which both represent a penetration depth of 30m, indicates that data do not correlate in the southwest, indicating possible interferences with the power line or fence.

The vertical 40-m EM-34 coil separation (see Figures 5-10 and 5-14) also depicts the anomaly associated with the drums depicted in the previous figures. The data show that permafrost generally was not indicated south of the Landfill and suggest possible thermal influences from the Chena River. The low conductivity readings northwest and northeast of the figure may represent deep permafrost and/or bedrock of the Birch Creek schist.

EMIX 34 Plus software was used to model several of the EM-34 survey transects completed across the Landfill Source Area (see Figure 5-6). The model generally was fit to a conceptual stratigraphic section consisting of the Landfill debris, a thaw zone existing beneath the Landfill, permafrost, and bedrock sections. The Landfill backfill and refuse area, and associated buried conductive debris (i.e., drums and metal), typically exhibit higher conductivity readings (i.e., greater than 10 mmhos/m) and were modeled as such. Areas that were identified as permafrost exhibited model results of less than 5 mmhos/m. Areas where no permafrost was encountered were interpreted as thaw zones from drainage areas or taliks or thermal influences from the Chena River and exhibited model results of typically 5 mmhos/m to 10 mmhos/m. A hard copy of all EMIX 34 Plus software data is provided in Appendix F.

Figure 5-15 represents a north-south transect (survey line 023) of the Landfill Source Area and was modeled to give an indication of depth to expected Birch Creek schist bedrock and the influence of the thermal effects on permafrost at the Chena River, and to help characterize a potential thaw bulb beneath the Landfill and areas of discontinuous permafrost. Figure 5-15 depicts the EMIX 34 Plus model interpretation and indicates a lack of permafrost beneath the Landfill, influences from the Chena River to the south, and permafrost and/or bedrock beneath the Landfill and from Birch Hill to the north. The modeled results provide a good comparison and are consistent with the other geophysical data from the Landfill and with the lithologic logs, and cross sections completed outside of the Landfill area and along the same general direction.

Figures 5-16 and Figure 5-17 represent east-west transects (survey lines 010 and 011) across the Landfill and depict the EMIX 34 Plus model interpretation. The figures provide a good indication of the presence of a thaw bulb existing beneath the Landfill with permafrost on the eastern and western sides of the Landfill. The figures generated by the model are consistent with data collected and observed in the other geophysical surveys, borehole, and cross sections completed in the same area and along the same general direction.

5.1.3.3 EM-47

TEMIX 47 model results were conducted across transect lines depicted in Figure 5-18. Figure 5-19 presents three cross sections (A-A', B-B', and C-C') of the EM-47 survey locations across the Landfill Source Area. Initial model results indicate saturation beneath the ground surface rather than the presence of permafrost. The data graphs presented are such that x-axis and y-axis scales are dependent on each discrete location. Therefore, the x-axis is dependent upon the conductive nature of the subsurface over which the instrument is set up. The y-axis depicts the depth calculated by the model itself and is not always consistent with neighboring locations. The penetrative depth at different locations is dependent upon the subsurface lithology; however, by viewing the graphs from the ground surface (depth equals 0m) to the depth penetrated, an indication of conductive and resistive layers beneath a discrete location can be determined.

The assumptions that were incorporated into the model included a Landfill height or thickness averaging 20 to 30 feet (6.5 to 10m) over an existing or historical ground surface, interbedded with conductive Landfill debris with lenses of soil cover and thaw zones, with observed and interpreted borehole data, and with typical values of resistivity of saturated and frozen lithologic units from previous reports and investigations.

Highly conductive layers (i.e., debris layers and saturated zones) are indicated by deflections to the left of the graphs (low resistivity), and low conductive layers (high resistivity) are indicated by deflections to the right of the graphs (i.e., permafrost, bedrock, dry sand, and gravel). Cross section A-A' is an east-west transect of EM-47 station locations across the Landfill (see Figure 5-19). Cross section A-A' indicates that the Landfill bottom or original surface is present at a depth of 6 to 10m BGS (19 to 33 feet), beneath which it appears that a saturated zone exists. The Landfill bottom was interpreted as having a resistivity of less than 1 ohm-m possibly because of the presence of a conductive thaw zone created by leaching and heat generation from the Landfill. The cross sections also indicate the presence of permafrost and/or saturated sand and gravel by evidence of the large deflections toward the right of the graphs in the east and west portions of the cross section. Permafrost extends from the near surface to approximately 30 to 40m BGS in the west portion of the cross section. The permafrost interpreted in the east portion is present at the near surface, but no total depth can be determined from the data. Permafrost and sand and gravel

were interpreted as having resistivity of generally greater than 100 ohm-m, while silt and other overburden were interpreted as having a resistivity of 10 to 100 ohm-m.

Cross section B-B' is a north-south transect of EM-47 station locations across the Landfill (see Figure 5-19). Cross section B-B' shows essentially the same features beneath the Landfill as cross section A-A', the bottom of the Landfill located at approximately 5 to 11m BGS (15 to 33 feet), underlain by a fairly conductive zone. The north portion of the cross section shows a considerable interpreted thickness of permafrost existing from the near surface to approximately 30m BGS. The south portion of the cross section shows very resistive material interpreted as permafrost in sand and gravel in the very near surface.

Cross section C-C' is directly west of the Landfill and provides a north to south interpretation of the subsurface lithology in this area (see Figure 5-19). The figure indicates that discontinuous permafrost is present, along with saturated sand and gravel, and possibly Birch Creek schist bedrock. The north portion of the cross section indicates either permafrost or a permafrost-bedrock combination in which a highly resistive zone was encountered at 2m BGS. This location was adjacent to Birch Hill and a schist bedrock exposure. The middle section and the south portion of the cross section show a varying thickness of permafrost and saturated zones interpreted from the station locations along the transect and are in agreement with the geologic cross section in this same area and of the same lineation.

The EM-47 cross sections are comparable to the rest of the geophysical data, including the EM-34 figures for the Landfill, which also indicate a thaw zone or saturated zone existing beneath the Landfill and the GPR data. The EM-47 cross sections also compare favorably with the geologic cross sections, generated for the Landfill, showing the same thickness of permafrost, sand, and gravel, and groundwater elevation.

5.1.3.4 Ground-Penetrating Radar

The GPR survey was designed to fill gaps in the location of permafrost and potential preferential transport pathways (taliks and other saturated zones), to supplement previous other permafrost surveys, and to aid in the characterization of the Landfill. GPR traverses are illustrated on Figure 5-20.

In general, the results indicate that permafrost is fairly discontinuous at the Landfill and that there appears to be an active layer, at the surface, in which complex bedding or other features were observed. There also appears to be several thaw zones or taliks encountered,

which may provide preferential transport of contaminants. GPR cross sections, from the west and southwest portion of the Landfill, representing permafrost features are shown in Figures 5-21 through 5-23, respectively.

Figures 5-21 and 5-22 depict portions of a north-south survey transect (line 1029 and 1023) located on the west edge of the Landfill, which passes directly over the location of borehole AP-6176, and follows approximately the same lineation of the geologic cross section A-A' in this area. Line 1029 (see Figure 5-22) represents results of the 100 MHz antenna, while line 1023 represents results of the 500 MHz antenna (see Figure 5-21). The most interesting subsurface anomaly associated with these transects is a strong reflecting subsurface feature that is interpreted as being typical of a talik zone or saturated equivalent. The feature appears to be representative of silt horizons found throughout the Landfill Source Area. The figures also show the approximate thickness of the active layer in the area, which is the thickness that freezes seasonally. The active layer in this area appears to be approximately 7feet-thick. Areas with little or no structure are interpreted as permafrost areas. The water table is located at approximately 7 feet BGS and was confirmed in the boring logs and with the Geoprobe™. The geologic interpretation of permafrost and a thaw zone beneath the permafrost is supported by the boring log of AP-6176, in which the thickness of permafrost was logged at approximately 6.5 to 23.5 feet BGS; a saturated zone was logged from 23.5 feet BGS to approximately 100 feet BGS.

Figure 5-23 depicts an east-west survey transect (line 1024) from the west edge of the Landfill perpendicular to GPR survey line 1029 and 1023 (see Figures 5-21 and 5-22). The most interesting subsurface features associated with this figure, as with the figure above, are the seasonal active layer, the groundwater table, and two reflecting subsurface features that are interpreted as talik zones. Areas with little or no structure are interpreted as permafrost areas. The water table is located at approximately 7 feet BGS in the transect and was confirmed with the GeoprobeTM.

GPR surveys were completed at the two Drum Trench Areas south of the Landfill. The surveys were attempted perpendicular to the surface lineation expression of the trenches. The data collected did not provide an effective graphical representation of the trenches and may be hampered by the vegetation and poor ground coupling of the antenna to the ground surface. This transect shows that the trenches are approximately 6-feet-deep and are fairly recognizable from the surrounding undisturbed lithology.

5.1.4 Groundwater

The monitoring well installation program for the RI included wells designed to sample representative groundwater from shallow and deeper aquifer zones adjacent to the Landfill and to provide supplemental information to data collected from the monitoring wells installed during previous investigations. Monitoring well installation objectives included identifying the horizontal and vertical extent of contamination, lithology, and permafrost; establishing groundwater depth and flow direction; delineating hydrogeologic parameters; and establishing pathways of preferred contaminant migration.

The groundwater investigation program utilized 15 previously installed monitoring wells and piezometers, and 10 newly installed wells (see Figure 2-1). Monitoring wells AP-6134, AP-6136, AP-6137, AP-6138, and AP-6139 were designed specifically to provide downgradient information and to monitor any potential contaminant movement through the permafrost-free channel located southwest of the Landfill, identified during the 1990 geophysical study, as well as to provide an indication of the extent of the channel. Wells AP-6134, AP-6136, and AP-6138 were designed to provide deep aquifer chemical quality and lithologic characteristics. Wells AP-6137 and AP-6139 were designed to provide shallow aquifer chemical quality and lithologic characteristics.

Wells AP-6130, AP-6131, AP-6132, and AP-6133 were completed to provide upgradient information about groundwater at the Landfill, as well as to provide background chemical data. Well AP-6132 was completed to help define groundwater flow direction and gradients and to determine influences from the Chena River. Wells AP-6130 and AP-6131 were designed to provide deep aquifer chemical quality and lithologic characteristics. Well AP-6140 was designed to provide shallow aquifer chemical quality and lithologic characteristics.

Following installation, the monitoring wells were surveyed for elevation and for northing and easting coordinates by the Corps.

During the CRREL investigation at the Landfill, approximately 11 additional monitoring wells were installed in the Landfill area to further characterize the site. Information from these monitoring wells is unavailable, except for limited groundwater flow probe data. The 1995 CRREL data with regard to the geology and hydrogeology of the Landfill were incorporated where possible.

5.1.4.1 Groundwater Elevations

Two potential aquifer zones were targeted for characterization during the RI: a shallow unconfined unit and a confined or semiconfined deeper aquifer unit. The two units may exist as a singular unconfined unit or, where permafrost is identified in the area, may be confined at depth.

Groundwater elevations from 1993 for two sets of shallow and deep monitoring wells (AP-5585/AP-5595 and AP-5588/AP-5589), one upgradient shallow well (117202), and the Chena River stage elevations are shown in Figure 5-24. Complete groundwater elevations for all the wells measured during the field activities are included in Appendix C. No changes in casing elevation after the winter season due to frost heaving were noted during the 1994 field activities.

Figure 5-24 depicts that the groundwater elevations in wells AP-5588, AP-5589, and 117202 rose in late September and declined after peaking in late September 1993. These observations are consistent with those observed in the USGS well 113 and discussed in Section 3 (see Figure 3-3). Wells AP-5585/AP-5595 show a gradual rise in the groundwater elevation of the shallow well AP-5585, which is consistent with the other wells but does not show the same range of response as with the other Landfill wells. The deep well (AP-5595) shows a large rise in groundwater elevation in late August and then little or no change in the groundwater elevation. This may be due to the proximity of permafrost near the well screen.

5.1.4.2 Groundwater—Surface Water Interaction

A comparison of groundwater elevations of the Landfill wells AP-5588, AP-5589, 117202, AP-5585, and AP-5595, as compared to the Chena and Tanana river stages, suggests that there is a hydraulic connection of the surface water and groundwater, as described in Section 3. The data show high and low groundwater elevations that suggest a correlation between the highest stage level of flow from the Chena River and the highest groundwater elevation, with a few days time lag between peaks in the data. This lag represents the time required for groundwater to flow from the Chena River to the groundwater system. Field data collected during the 1993 and 1994 field activities reflect that the Chena River stage elevation is important in controlling recharging and discharging to the alluvial aquifer and affecting changes in flow direction, elevation, and gradients. The Tanana River shows little

influence on groundwater in the Landfill Source Area, based on available data obtained during the 1993 and 1994 field activities.

5.1.4.3 Groundwater Flow Direction and Gradients

Groundwater elevation contours for the shallow and deep aquifer zones at the Landfill during the 1993 and 1994 field events are presented in Figures 5-25a, 5-25b, 5-25c, 5-26a, and 5-26b. The groundwater contours were constructed using all available wells when a maximum number of wells could be measured in a day. This approach provided coverage over the full extent of the Landfill investigation area. In several instances, the shallow and deep groundwater contours do not cover the entire Landfill investigation area; therefore, several groundwater elevations from wells are missing because of access problems, dry or frozen wells, or wells not yet installed. Several anomalies between wells were noted. Wells AP-5593, WLF-1, WLF-2, and WLF-3 are completed in the same general location at the same relative depth, yet the difference in elevation between AP-5593 and the WLF wells is approximately 2.5 feet. Figures 5-25 and 5-26, representing the shallow groundwater, were drawn without the WLF wells to examine the flow patterns, should these data be in question. It is important to note that the anomaly identified at this well cluster could be a result of well construction or influences of vertical flow caused by permafrost. Groundwater in the shallow aquifer zone generally flowed south-southwest toward the Chena River during October 1993 field activities and west-southwest during July 1994 field activities, coincident with the past records of groundwater flow in the area (E & E 1990). Of particular interest in Figure 5-25a is the apparent mounding of water on the Landfill; this water extends as a tongue from Birch Hill southward. Also, an anomaly on the eastern edge of the Landfill appears to indicate a groundwater flow zone away from the Landfill. These groundwater transport pathways also are suggested in the CRREL assessment (CRREL 1995). Figure 5-25b does not incorporate the WLF series of wells and shows a fairly consistent groundwater flow direction to the southwest toward the Chena River. Figure 5-26a depicts the 1994 shallow groundwater elevations and shows a fairly consistent flow direction in comparison with the regional flow expected in the area. Groundwater in the deeper aquifer zone flowed west-northwest for 1993 and 1994 field activities, coincident with the regional flow gradient. Groundwater in the shallow zone appears to be partially influenced by a gravity-driven baseflow component coming off of Birch Hill in the form of runoff and/or baseflow particularly during the 1993

field activities. Figure 5-27 is a three-dimensional block diagram of the 1994 shallow groundwater elevations, and it appears to show a mounding effect below the Landfill. This feature also was observed during the 1993 field activities.

Birch Hill and the Chena River may be influencing the deeper groundwater flow because of boundary effects of the Birch Creek schist bedrock and recharge of the aquifer by the Chena River, which may be responsible for slight changes in the groundwater direction flow component when westward groundwater flow directions are observed. Data collected by CRREL on the north side of the Chena River across from the Railcar Off-Loading Facility (ROLF) indicate that the Chena River influences the direction of flow of the groundwater in a relatively short period of time, one week recharging the aquifer with flow away from the river, the next week receiving groundwater discharge with flow toward the river (CRREL 1994). Figure 5-28 depicts a three-dimensional block diagram of water levels from the deep aquifer for 1994 field activities. The figure shows the influence of the Chena River moving toward the northwest, influencing the deep groundwater elevations.

The average horizontal groundwater gradients across the Landfill in the shallow aquifer ranged from approximately 0.0002 (1 ft/mile) to 0.008 (42 ft/mile) for data collected in 1993 and 1994. Gradient was established between 117202 and at AP-5593 for 1993 data, and AP-6132 and AP-6139 for 1994 data. Groundwater gradients for the 1993 period represent the end of the seasonal high groundwater elevations and likely reflect the peak groundwater elevations. Groundwater gradients from the 1994 period likely represent recharge influence from the Chena River. Gradients established at the Tank Farm ranged from 0.002 to 0.0004.

Average horizontal groundwater gradients across the Landfill in the deeper aquifer are approximately 0.002 (10.5 ft/mile) for 1993 and 1994 data, with little change in flow direction or gradient. The gradients were established between AP-5589, and AP-6134. Horizontal gradients south of the Landfill, particularly in the southeast, reflect recharge influence from the Chena River and impose a north-northwest flow component to the overall groundwater flow system. This is consistent with previous studies, during the same relative time period (September 1988) for this area, which indicate a low hydraulic gradient of 0.01 to 0.02 away from the Chena River for the shallow aquifer (WCC 1988). Corps modeling data from October 1985 also suggest a northward component of flow from the Chena River toward

the Landfill, but the model calibration was made for one round of groundwater elevations and did not include any monitoring wells north of the Chena River (USACE 1986).

A comparison of groundwater elevations in paired monitoring wells AP-5585/ AP-5595, AP-5588/AP-5589, and AP-5593/AP-5594 was performed in order to identify vertical groundwater gradients at the Landfill (see Figure 5-29). The well pairs represented topographically upgradient or cross-gradient wells AP-5593/AP-5594, and downgradient wells AP-5585/AP-5595 and AP-5588/AP-5589 monitoring well pairs. Vertical hydraulic gradients in AP-5593/AP-5594 varied from approximately 0.0015 upward to 0.0035 downward for 1993 and were reflecting predominantly a downward movement of water. A vertical hydraulic gradient of approximately 0.0008 downward was determined for 1994 field activities. Vertical hydraulic gradients in AP-5585/AP-5595 varied from approximately 0.03 to 0.054 upward for 1993 and reflected a strong upward movement of water. A vertical gradient of approximately 0.04 upward was determined for 1994 field activities. Vertical hydraulic gradients in AP-5588/AP-5589 varied from approximately 0.0005 to 0.004 downward for 1993. A vertical gradient of approximately 0.005 downward was determined for 1994 field activities. The vertical gradients probably coincide with the rise and fall of the Chena River stage, representing recharge and discharge of the aquifer and diurnal and other time-dependent change.

Groundwater flow directions and gradients in the shallow aquifer indicate source potential variations between the October 1993 data and July 1994 data, while groundwater flow directions and gradients for the deeper aquifer at the Landfill did not change appreciably during the field activities of 1993 or 1994.

5.1.4.4 Aquifer Testing

Limited slug tests were performed at the Landfill to confirm aquifer hydraulic parameters at the Landfill. Because of the large volumes of water likely to be generated for pump tests, it was decided to perform the slug tests to obtain generalized hydraulic values. Because the slug tests provide general aquifer parameter information, specific aquifer performance values have not been obtained.

Should the selected remedial action involve groundwater extraction or in situ groundwater treatment, additional groundwater hydraulic parameters may be required. It will be necessary to obtain the required parameters, depending on the remedial action, during the

remedial design phase. Since the landfill has been a source of investigation and study by others (i.e., CRREL and USGS), other data collected and reported also should be evaluated during remedial design.

Data generated during the slug tests enabled the calculation of hydraulic conductivity for the immediate area surrounding the well screen. Although the conductivity value determined may be influenced by skin effects (the screen filter sand and formation smearing by the drilling bit), the values can give a good estimate of the subsurface hydraulic properties. The computer program GWAP (1987) was used to perform the Cooper *et al.* method (1967), while a Lotus 123 spreadsheet was used to help estimate the data for analysis using the Hvorslev method (1951). A hard copy form of the aquifer testing data is provided in Appendix D.

Horizontal hydraulic conductivities calculated for the slug tests performed at AP-6140 indicate values of approximately 4.9×10^{-3} ft/second to approximately 6.8×10^{-3} ft/second. Transmissivity values calculated for a 50-foot saturated thickness range from approximately 158,000 gpd/ft to 220,000 gpd/ft. Previous tests conducted at the Landfill and at other Fort Wainwright locations were comparable in determination of hydraulic values to the slug test results. Values determined for the Landfill are approximately an order of magnitude higher than comparable results from the Tank Farm (alluvial aquifer conductivity of approximately 5.6×10^{-4} ft/second) and the range of values determined from tests near the airfield (conductivity range of approximately 6×10^{-5} ft/second to 3×10^{-4} ft/second). A 9-hour pumping test at MW-1 and the Ski Lodge wells indicated a transmissivity of 100,000 to 300,000 gpd/ft and a specific yield of 0.07 to 0.56 (WCC 1989; USACE 1991b, 1992d). Based on a 50-foot saturated thickness, a hydraulic conductivity of 3×10^{-3} ft/second to 9×10^{-3} ft/second is indicated from the pumping test data. The observation wells used during the pumping tests showed little or no drawdown influence from the pumping.

5.1.4.5 Groundwater Travel Times

Hydraulic conductivity (K) is a value representing the rate at which groundwater flows through a unit area of aquifer material under a constant hydraulic gradient (dh/dl). Transmissivity (T) is the rate of flow under a hydraulic gradient through a saturated cross sectional width of the aquifer. The K and T values aid in determining contaminant migration characteristics used in evaluating the possible extent of contamination. Groundwater flow

velocities can be estimated for the aquifer zones beneath the Landfill by utilizing values determined during aquifer testing. Flow velocities were calculated using the Darcy velocity equation:

v = (K/n)(dh/dl)

Where:

K = Hydraulic conductivity

n = effective porosity

dh/dl = Hydraulic Gradient

Darcy velocities were determined for the two aquifer zones underlying the source area. Values were calculated using an assumed effective porosity of 0.30 for a sand and gravel aquifer, hydraulic conductivities determined from the aquifer, and differences in elevation head potential between wells completed in shallow and deep aquifer zones. The overall low-range velocity (shallow aquifer) across the Landfill was determined to be approximately 3.2×10^{-6} ft/second (100 ft/year) and the overall high-range velocity (shallow aguifer) was calculated at approximately 1.8×10^{-4} ft/second (5,600 ft/year). The overall low-range velocity (deep aquifer) across the Landfill was determined to be approximately 3.2 \times 10⁻⁵ ft/second (1,000 ft/year) and the overall high-range velocity (deep aquifer) was calculated at approximately 4.5×10^{-5} ft/second (1,400 ft/year). The groundwater flow velocities are presented as an estimation of groundwater flow across the Landfill and may not represent the actual movement processes occurring. Groundwater velocities can vary because of changing factors within the flow system, such as heterogeneities in the lithology, permafrost, precipitation events, or stage changes in the Chena River. Velocities determined from the Tank Farm (OU-3) indicate that groundwater at the Landfill is at the upper range of velocities in comparison and up to one order of magnitude higher. Groundwater velocities determined by CRREL using flow probes at the Landfill indicated values ranging from approximately 1.4×10^{-5} ft/second (450 ft/year) to 4×10^{-5} ft/second (1,300 ft/year); CRREL 1995).

Groundwater conductivities and velocities calculated from slug tests performed at landfill wells are estimates within a range of expected values. Variations of calculated values could be indicative of the techniques utilized. For example,

- OU-3 (Tank Farm) values were determined using a fixed volume solid slug test. Values were considered underestimated due to hydraulic restrictions through pre-pack screen constructions;
- Values at MW-1 and the Ski Lodge well were determined through the use of a pump test (groundwater extraction and recovery);
- Values provided by CRREL were determined using flow probes to directly measure flow direction and velocity at individual wells.

The slug tests performed at the OU-4 landfill wells were pneumatic slug tests. Values calculated attempted to compensate for hydraulic restrictions that may be present in the prepack well constructions. Values obtained are considered acceptable within the range of values expected from the previous and on-going studies performed. It should be reiterated that variations of hydraulic parameters also may exist in localized areas influenced by permafrost. Prior to remedial action, current groundwater studies (i.e., CRREL) should be evaluated and compared to data collected from previous studies.

5.1.4.6 Hydrogeochemistry

Chemical analyses, including cation and anion analysis of groundwater, were performed at the Landfill to characterize the chemistry of the underlying aquifer and to provide insight into surface water and groundwater interactions and contaminant fate and transport studies. An evaluation of the general groundwater chemistry in the immediate vicinity of the Landfill for wells AP-5588/AP-5589, AP-5593/AP-5594, and AP-5585/AP-5595 was completed using Stiff and Piper diagrams as a characterization tool (see Figure 5-30). Stiff diagrams are used to provide information on areal trends that may exist in an area, while Piper diagrams give an indication of chemical trends that may exist. A general mass balance for the groundwater samples from the monitoring wells was calculated for the cations and anions determined from laboratory analysis, and hard copy forms of the hydrogeochemical data are provided in Appendix H.

Groundwater samples submitted for geochemical analysis, in which the pH is less than 6 and the mass balance of cations to anions is over 5%, are considered unusable for evaluation. This is because of the limiting geochemical reactions, including the analytical results being inaccurate; other constituents being present that are not used in the balance; or organic ions present in significant quantities. Based on analysis, data from AP-5594 did not

meet a cation/anion balance of less than 5% but were nearer 10%. This indicates that an ion may be missing from the balance calculation and that this data should be examined with caution.

An examination of the Stiff and Piper diagrams indicate that there is a distinct difference in water samples collected upgradient of the Landfill and those collected downgradient. This indicates that waters downgradient of the Landfill within the interpreted transport pathway (i.e., southwest drainage) have a higher total ionic content, which could indicate landfill leachate generation. The mass balance of the water samples also indicates that ions are being added to the system downgradient of the Landfill; specifically, chloride ion concentrations, which are effective indicators of Landfill leachate, are six times as high as upgradient samples.

Chemical analyses of the Chena River surface water samples from SD-10 and SD-14 locations also were performed to provide information on groundwater and surface water interactions that may exist at the OU-4 source areas. The Chena River is discussed here because the vicinity of the Landfill Source Area is closest to the Chena River and appears to have more influence on the groundwater quality than the other source areas. An evaluation of the general surface water chemistry of "upgradient" and "downgradient" Chena River waters was completed using Stiff and Piper diagrams as a characterization tool (see Figure 5-31). A general mass balance for the groundwater samples was also calculated for the cations and anions determined from laboratory analysis, and hard copy forms of the hydrogeochemical data are provided in Appendix D. A comparison of surface water samples from SD-10 and SD-14 indicate that the samples are essentially of the same areal and chemical trends.

A comparison of areal and chemical trends of the Chena River surface water and upgradient Landfill groundwater (AP-5593/AP-5594), indicates that the Chena River water resembles groundwater, based on Stiff diagrams, which are less comparable to the wells downgradient of the Landfill (AP-5585, AP-5588, and AP-5589). The Pipir diagrams indicate that Chena River water and the groundwater found in AP-5585 and AP-5589 are the same water mass.

5.1.4.7 Groundwater Turbidity

Turbidity was measured at the time of groundwater sampling but was not used as a criterion for well development as approved in the MP (E & E 1993a). The turbidity values

measured at wells across the fort historically have yielded low to very high turbidity values. The sampled values of turbidity and the groundwater sample photographs (see Appendix D) were reviewed for potential turbidity trends geographically.

An areal comparison of turbidity values measured from the shallow monitoring wells at the Landfill indicates that the higher relative values of turbidity appear to correlate to potential transport pathways. The southwest drainage monitoring wells and those to the east of the Landfill exhibited turbidity values exceeding 15 NTUs. This was the case for the 1993 and 1994 data. This comparison of turbidity values, however, is a broad generalization of turbidity and is not intended to be a known pattern to exist, given the variables that can effect turbidity. Turbidity values ranged from 5 NTUs to more than to 200 NTUs.

5.1.5 Ecology

The Ecological Risk Assessment contains a thorough review and evaluation of the ecology at the Landfill Source Area. The following description summarizes those findings.

Aside from the active portions of the Landfill, the Landfill and the surrounding area is vegetated. Grasses and brush cover the Landfill's sloping sides. An approximate 50-foot strip of brush and grass abuts the west, south, and southeast boundaries of the elevated portion of the Landfill. Mixed upland and wetland forests surround the grassy areas. Several small open scrub/shrub wetland areas south of River Road may be the result of anthropogenic activities. Two drainage ditches, which extend southeast and southwest from the Landfill, are densely vegetated and rarely contain flowing water.

North of the Landfill is a mixed, open and dwarf birch and diamond leaf willow wetland. Birch Hill, which is vegetated with mixed paper birch and white spruce forest, represents the north boundary of the wetland.

Immediately east of the Landfill is a pond surrounded by a grass wetland. These two habitats give way to mixed wetland forests and eventually to upland white spruce/paper birch forests.

The forested and grassy areas of Landfill Source Area provide habitat for a diverse mammal and avian population, but the Landfill itself is a potential food source for small mammals and birds. Ravens were observed feeding in this area during the field investigation. The open wetlands provide seasonal habitat for waterfowl.

The Chena River is the main aquatic resource in the vicinity of the Landfill. It represents a diverse aquatic food web that includes aquatic vegetation, invertebrates, fish, waterfowl, and mammals.

5.2 NATURE OF CONTAMINATION

This section summarizes analytical results, by media, generated during the 1993 and 1994 field seasons at the Landfill Source Area. An overview of the nature of contamination is followed by a discussion of the extent, or spatial distribution, of contamination. A complete list of the analytical results is included in Appendix I. Within each media, inorganic results are discussed separately from organic compounds. Within the organic results discussion, field laboratory results are discussed first, followed by petroleum-related compounds, VOCs, and pesticides. Samples collected at the Landfill were analyzed by the field laboratory, except for groundwater samples. The results were used to make field decisions such as determining where further sampling was required or locating boreholes and wells. The field analytical results are presented in this section for the sake of completeness; however, they were not used to determine the nature or extent of contamination. To assist in putting the nature of contamination into a human health perspective, each discussion includes those chemicals considered to be COPCs at the Landfill. An overview of the procedure for selection of COPCs follows.

A conservative risk-based screening procedure was used to select COPCs at the Landfill. This screening procedure was identical to that used for the OU-4 Baseline Human Health Risk Assessment, which was amended from the screening procedure used in the Approach Document for the Baseline Human Health Risk Assessment (E & E 1994), based on the availability of updated toxicity information and comments received from the Corps, ADEC, and EPA. The Approach Document identified those compounds that pose a potential risk to human health. The RI builds on this information by providing more detail on the nature and extent of these compounds at each OU-4 source area. The Baseline Human Health Risk Assessment quantitates the risks posed by those compounds and further defines those that potentially pose a substantial risk to the public. Chemicals detected at the Landfill were screened against RBCs for residential soil and drinking water derived from EPA, Region 3, guidance (EPA 1994a). EPA, Region 10, specifies the use of this guidance for screening purposes because it reflects the most current toxicity criteria available (EPA 1994d). EPA's

current action level for lead in drinking water of 15 μ g/L (EPA 1991) and EPA's updated lead in soil screening concentration of 400 mg/kg was used for this screening process (EPA 1994e).

To be conservative, chemicals detected in surface soil, subsurface soil, ash, and sediment were compared to the RBC equivalent to a 1×10^{-7} excess cancer risk, or a hazard quotient of 0.1. All chemicals detected in groundwater and surface water were compared to the RBC equivalent to a 1×10^{-6} excess cancer risk, or a hazard quotient of 0.1. Chemicals exceeding one or both of these criteria were considered to be COPCs. Chemicals detected in surface or groundwater samples also were compared to State of Alaska Water Quality Standards (18 AAC 70) and MCLs (18 AAC 80). Although RBCs do not exist for petroleum products, they have been included in analytical tables for the sake of comparison because ARARs have not been established. Petroleum contamination in soil was compared to values in the cleanup matrix scoresheet from the Interim Guidance for Non-UST Contaminated Soil Cleanup Levels, Guidance No. 001, Revision No. 1, July 17, 1991 (ADEC 1991). DRO and GRO analyses were not conducted for every sample. For these samples, the results of the fuel ID analysis were compared to the matrix values. Bunker C-range organics were compared to the value for residual-range petroleum hydrocarbons because analytically they would be quantitated within that range. The State of Alaska has no specific cleanup level for petroleum in water, but does not allow the presence of a visible sheen, discoloration, film, odor, or taste, according to organoleptic tests. Because these tests were not conducted, it was assumed that petroleum hydrocarbons were classified as COPCs if detected in water.

Inorganics were eliminated as COPCs if they were present at naturally occurring concentrations (i.e., background) at OU-4. Concentrations first were compared to the Corps-recommended background data for arsenic, barium, cadmium, chromium, and lead in soil and groundwater because these values have been established statistically (Corps 1994) and are presented in Table 3-3. Sample results then were compared to the maximum detected background concentration in each environmental medium at each source area. Analytical results from ash samples were compared with background surface soil concentrations. Background samples were collected from locations believed to be unaffected by site-related contaminants because of their upgradient locations and distance from known or suspected contamination sources. Inorganics for which Corps-recommended background values and

RBCs were unavailable were compared to the range of concentration of those elements in Alaska soil (Gough 1988). Results are presented in the following sections.

Aluminum, calcium, iron, magnesium, potassium, and sodium were eliminated from the nature and extent of contamination discussions because they are not associated with toxicity to humans under normal circumstances (EPA 1991) and are common constituents in naturally occurring minerals in geologic systems. However, in several instances, the maximum detected concentration of aluminum exceeded background concentrations by more than three times. At that point, it was compared to the normal range of aluminum in Alaska soil. Naturally occurring constituents, such as aluminum, are present along drainages (i.e., southwest drainage) at relatively higher concentrations than surrounding soils. COPCs such as barium, however, do not exhibit higher levels, suggesting that the inorganics along drainages are not originating from the Landfill.

Any chemical existing at concentrations even approaching a potential risk to human health was identified using this conservative screening approach. A more detailed description of the human health risk-based COPC screening procedure is presented in the OU-4 Baseline Human Health Risk Assessment.

Table 5-3 lists the RBCs and source area-specific background concentrations used for comparison purposes.

5.2.1 Nature of Ash Contamination

Eight ash samples were collected from the cover of the active Landfill. A summary of detected constituents is presented in Table 5-4. A discussion of the constituents follows.

5.2.1.1 Inorganic results

Aluminum was detected at all sampling locations at concentrations ranging from 8,230 to 49,500 mg/kg. Seven locations exceeded the background soil concentration of 11,700 mg/kg. However, references cite aluminum concentrations ranging from 1.2% to 10% (12,000 to 100,000 mg/kg) in Alaska soil (Gough 1988), indicating concentrations in ash may still be present in naturally occurring concentrations. An RBC does not exist for aluminum.

Arsenic was detected at all eight sampling locations, at concentrations ranging from 5 to 14 mg/kg. The Corps-recommended background value for soil north of the Chena River

is 17 mg/kg. Background arsenic surface soil sample concentrations collected from the Landfill were 10 and 27 mg/kg. Since arsenic values were in the same range as concentrations detected in background surface soil at the Landfill and less than the Corps-recommended background value (Corps 1994), arsenic is not considered a COPC.

Barium was detected in all of the source area ash samples, at concentrations ranging from 92 to 3,130 mg/kg. The Corps-recommended background value for barium in soil north of the Chena River is 275 mg/kg. Barium concentrations in collected background surface soil ranged from not detected above 2 to 294 mg/kg. The RBC for barium is 550 mg/kg. Eight samples contained barium above the background concentration; seven samples were above the RBC.

Total chromium was detected in all of the ash samples, at 14 to 52 mg/kg. Chromium concentrations in collected background surface soil ranged from 5 to 22 mg/kg. The Corps-recommended background value for chromium in soil north of the Chena River is 35 mg/kg. The RBC for chromium is 39 mg/kg. Four samples contained chromium above the background value; three samples were above the RBC.

Cobalt was detected in all of the ash samples, at concentrations ranging from 8.2 to 23 mg/kg. Background surface soil from the Landfill contained cobalt at concentrations ranging from 6.4 to 9.7 mg/kg. Seven Landfill ash locations exceeded this background concentration; however, references cite cobalt present in Alaska soil and surficial materials at concentrations up to 55 mg/kg (Gough 1988).

Copper, lead, nickel, and zinc were detected in all the ash samples, at concentrations less than the RBCs. Several samples exceeded the maximum surface soil background concentrations for copper and nickel. Lead and zinc were not detected above background concentrations.

Manganese was detected in all of the ash samples, at concentrations ranging from 196 to 522 mg/kg. Background surface soil samples contained manganese at concentrations ranging from 120 to 299 mg/kg. The RBC for manganese is 39 mg/kg. Six samples exceeded the maximum background concentration. All samples exceeded the RBC.

Mercury was detected at one sample location and silver was detected at two locations at concentrations less than risk-based screening concentrations. Mercury and silver also did not exceed background concentrations.

Vanadium was detected in all of the ash samples, at 26 to 131 mg/kg. Background surface soil at the Landfill contained vanadium at 18 to 36 mg/kg. The RBC for vanadium is 55 mg/kg.

Barium, chromium, manganese, and vanadium are the principal contaminants of concern in ash at the Landfill.

5.2.1.2 Organic Results

Ash samples were not analyzed by the field laboratory for FSVOCs or FSPH. PCBs, BNAs, herbicides, and fuels were analyzed for but not detected by the off-site laboratory. The samples were not analyzed for VOCs by the off-site laboratory. All ash samples were analyzed for pesticides; DDT and its derivatives and dioxin/furan congeners were detected.

4,4'-DDD was detected in one ash sample, 4,4'-DDE was detected in two samples, and 4,4'-DDT was detected in four ash samples. All of these compounds were detected at less than the corresponding RBCs.

All of the ash samples were analyzed for dioxin and furan congeners. Four dioxin and furan congeners were detected. 1,2,3,4,6,7,8,9-octachlorodibenzofuran (OCDF) was detected at one of the eight locations, at less than the RBC. 1,2,3,4,6,7,8-heptachlorodibenzofuran (HpCDF) was detected in two ash samples, at less than the RBCs.

Two dioxin compounds were detected in six of the eight ash sample locations. 1,2,3,4,6,7,8,9-octachlorodibenzo-p-dioxin (OCDD) was detected at six locations, at concentrations ranging from 37 to 600 parts per trillion (pg/g). Also of concern is 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin (HpCDD), which was detected at six locations, at concentrations ranging from 5.3 to 53 pg/g. The RBCs of 430 and 53 pg/g, respectively, were exceeded at one sample location (ASH-4). The only organic COPCs in the Landfill ash are 1,2,3,4,6,7,8,9-OCDD and 1,2,3,4,6,7,8-HpCDD. Relative toxic equivalence factors (TEF) for the dioxin/furan isomers exceeding RBCs are discussed in the risk assessment.

5.2.2 Nature of Surface Soil Contamination

Thirty-five surface soil samples were collected from the Landfill Source Area. Table 5-5 lists the constituents detected in surface soil collected outside the ash cover at the Landfill.

5.2.2.1 Inorganic Results

Elements detected in more than 95% of the samples but below RBCs included cobalt, copper, nickel, and zinc. Copper was detected above the background concentration in 23 samples, nickel in 17 samples, and zinc in 16 samples.

Cobalt was detected at 28 sample locations, at concentrations ranging from 5.3 to 16 mg/kg. Background surface soil contained cobalt at concentrations of 8.4 mg/kg and 9.7 mg/kg. Fifteen locations exceeded this background concentration; however, these concentrations were below published background concentrations of up to 55 mg/kg in Alaska soil and surficial materials (Gough 1988).

Mercury was detected in one surface soil sample location, at a concentration exceeding background, but not the RBC. Silver was detected in four surface soil samples below the RBCs. Silver was not detected in background samples.

Aluminum was detected in all surface soil samples at concentrations ranging from 4,870 to 38,000 mg/kg. Background sample concentrations were 10,600 mg/kg and 11,700 mg/kg. Thirteen locations exceeded this background concentration; however, these values are within the published range of background aluminum concentrations in Alaska soil and other surficial material of 12,000 to 100,000 mg/kg (Gough 1988). An RBC does not exist for aluminum.

Arsenic was detected above the RBC (0.037 mg/kg) in all Landfill surface soil, at concentrations ranging from 1.2 to 21 mg/kg. Arsenic concentrations in the Landfill background samples ranged from 8.5 mg/kg to 10 mg/kg. The Corps-recommended background concentration for arsenic in soil north of the Chena River is 17 mg/kg. Two site source locations exceeded the Corps-recommended background concentration.

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Barium was detected in all the Landfill surface soil, at concentrations ranging from 1.5 to 559 mg/kg. Barium concentrations in the background samples collected from the Landfill Source Area were 110 mg/kg and 165 mg/kg. One source area location exceeded the Corps-recommended background concentration of 275 mg/kg and the RBC of 550 mg/kg.

Cadmium was detected in one surface soil sample at 11 mg/kg, which exceeds the Corps-recommended background value of 1.7 mg/kg and the RBC of 3.9 mg/kg.

Chromium was detected in all surface soil, at concentrations ranging from 9 to 42 mg/kg. Concentrations of chromium in background samples were 19 mg/kg and 22

mg/kg. One location exceeded the Corps-recommended background concentration of 35 mg/kg and the RBC of 39 mg/kg.

Lead was detected in all surface soil samples, at concentrations ranging from 3 to 2,480 mg/kg. Lead concentrations in the background samples were 8.8 mg/kg and 13 mg/kg, which is less than the Corps-recommended background concentration of 25 mg/kg for lead in soil north of the Chena River. The RBC for lead is 400 mg/kg. One location exceeded the Corps background concentration and RBC.

Manganese was detected above the RBC of 39 mg/kg in all Landfill surface soil, at concentrations ranging from 107 to 530 mg/kg. Background manganese concentrations were 206 mg/kg and 299 mg/kg. Sixteen samples exceeded the background concentration; all samples exceeded the RBC of 39 mg/kg.

Vanadium was detected in all Landfill surface soil, at concentrations ranging from 10 to 56 mg/kg. Vanadium concentrations in the background surface soil were 36 mg/kg. The RBC for vanadium is 55 mg/kg. Thirteen surface soil samples exceeded the background concentration; one sample also exceeded the RBC.

Using this screening criteria, the inorganic contaminants of concern in Landfill surface soil are arsenic, barium, cadmium, chromium, lead, manganese, and vanadium.

5.2.2.2 Organic Results

Twenty surface soil samples were analyzed for FSPHs by the on-site laboratory, and 30 samples were analyzed for FSVOCs. FSPHs were detected in six surface soil samples, at concentrations ranging from 25 to 150,000 mg/kg. Toluene and trichloroethene each were detected in one surface soil sample, at 18.7 μ g/kg and 89 μ g/kg, respectively.

Table 5-5 lists the organic compounds detected in Landfill surface soil by the off-site laboratory. TRPH was detected in 29 of the 33 surface soil samples analyzed by the off-site laboratory, at concentrations ranging from 14 to 326,000 mg/kg. Bunker C as No. 6 diesel (bunker C-range organics) was detected in 32 of the 33 surface soil samples, at concentrations ranging from 17 to 124,000 mg/kg. One sample contained DROs at 12 mg/kg; the corresponding duplicate sample did not contain detectable levels of DROs. An additional sample contained DROs at 31 mg/kg. Neither TRPH nor bunker C were detected in that sample. The levels of bunker C in two samples exceeded the State of Alaska cleanup level of 2,000 mg/kg for residual-range petroleum hydrocarbons.

Although the project laboratory analyzed for PCBs and herbicides, none were detected. Compounds detected at less than RBCs include 4,4'-dichlorodiphenyldichloroethane (4,4'-DDD), acetone, endrin, methylene chloride, and pyrene. Endrin and pyrene were detected in one surface soil sample, acetone was detected in four samples, 4,4'-DDD was detected in 13 samples, and methylene chloride was detected in 22 samples.

Compounds that were detected but do not have RBCs for comparison include dichloroprop; 1,1,1-trichloroethane; and trichloroethene. These three compounds each were detected in one sample.

Bis(2-ethylhexyl)phthalate was detected in one sample at a concentration of 43.5 mg/kg, exceeding its RBC of 4.6 mg/kg.

4,4'-DDE was detected in 14 samples at concentrations ranging from 3.4 to 191 μ g/kg. A background sample contained 4,4'-DDE at 41 μ g/kg. The RBC for 4,4'-DDE is 190 μ g/kg. One sample exceeded this concentration.

4,4'-DDT was detected in 16 samples at concentrations ranging from 4 to 692 μ g/kg. The background samples contained 4,4'-DDT at concentrations of 100 and 144 μ g/kg. The RBC for 4,4'-DDT is 190 μ g/kg. Three samples exceeded this concentration.

Dieldrin was detected at four surface soil locations at the Landfill. Concentrations ranged from 7.1 to 99 μ g/kg. Dieldrin was not detected in the background surface samples. The RBC for dieldrin is 4 μ g/kg. All samples exceeded this concentration.

Elevated concentrations of polynuclear aromatic hydrocarbons (PAHs) were detected at background location AP-6131. These results are not representative of site conditions at the Landfill because it was determined after fieldwork was completed that AP-6131 was located downgradient of a leaking UST; therefore, these results are not presented in Table 5-5 and were not used for background comparison purposes.

Based on the screening criteria, organic COPCs in Landfill surface soil are bis(2-ethylhexyl)phthalate; 4,4'-DDE; 4,4'-DDT; and dieldrin.

5.2.3 Nature of Subsurface Contamination

Table 5-5 lists the organic and inorganic chemicals detected in subsurface soil at the Landfill. One subsurface soil sample location (AP-6140) exceeded the background concentrations for the following inorganics: aluminum, cobalt, copper, manganese, nickel, vanadium, and zinc. Manganese also exceeded the RBC. Aluminum, copper, and nickel exceeded

background concentrations in one additional sample. Vanadium exceeded background concentrations in two additional samples. Acetone and methylene chloride (common laboratory contaminants) were detected in 13 out of 17 and eight out of 17 samples, respectively. Bunker C (nine out of 15 samples), TRPH 12 out of 15 samples), diesel (one out of 15 samples), and kerosene (one out of 15 samples) also were detected. The maximum detected concentrations for all detected analytes occurred in the sample from the background borehole, AP-6131, which reflects contamination from a leaking UST adjacent to the Ski Lodge and unrelated to the Landfill Source Area. Therefore, this sample was not included in Table 5-5 and was not used for background comparison purposes. Based on the screening criteria, manganese is the only COPC present in subsurface soil at the Landfill.

5.2.4 Nature of Sediment Contamination

Twenty-four sediment samples were collected at the Landfill Source Area.

5.2.4.1 Inorganic Results

Table 5-6 lists the chemicals detected in sediments at the Landfill Source Area. Elements detected at less than RBCs include mercury (detected at two sample locations) and silver (detected at one source area location and one background location). Elements less than RBCs also include aluminum, chromium, copper, lead, nickel, vanadium, and zinc, which were detected in all the sediments collected from the Landfill; however, mercury, chromium, copper, lead, nickel, and vanadium were detected at concentrations exceeding background.

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Cobalt was detected at six locations, at concentrations ranging from 5.9 to 14 mg/kg. Cobalt was not detected in background sediment samples collected from the Landfill Source Area; however, the published mean value for cobalt in stream and lake sediments from Alaska is 18 mg/kg (Gough 1988).

Arsenic was detected in all source area sediment samples, at concentrations ranging from 1.1 to 12 mg/kg. Arsenic concentrations in the collected background sediments ranged from not detected at 3 to 38 mg/kg. No samples exceeded the background value. The RBC for arsenic is 0.037 mg/kg.

Barium was detected in all the sediments collected from the Landfill, at concentrations ranging from 50 to 1,040 mg/kg. Background sediment samples collected at the Landfill

contained barium concentrations of 120 and 341 mg/kg. The RBC is 550 mg/kg. One location exceeded the RBC and the background concentration.

Manganese was detected in all the sediments collected from the Landfill, at concentrations ranging from 67 to 1,070 mg/kg. Background sediment samples collected at the Landfill contained manganese concentrations of 48 mg/kg and 410 mg/kg. The RBC for manganese is 39 mg/kg. Four locations exceeded the background concentration. All samples exceeded the RBC.

Based on the screening criteria, inorganic COPCs in Landfill sediments are barium and manganese.

5.2.4.2 Organic Results

FSPH analysis was not performed on Landfill sediment samples. FSVOCs were performed on 22 sediment samples. No volatile were detected by the on-site laboratory.

Sediments were analyzed for BNAs and PCBs, but none were detected. TRPH was detected at eight sediment locations collected from the Landfill Source Area. Concentrations ranged from 26 to 374 mg/kg. TRPH was detected in a background sample at 54 mg/kg. Bunker C as No. 6 diesel (bunker C-range organics) was detected in 20 sediment samples, including the two background sediments. Concentrations ranged from 7.5 to 382 mg/kg. One of the background samples contained bunker C-range organics at 4,060 mg/kg. DROs were detected in one location, at 8.3 mg/kg. Only the background sample exceeded State of Alaska cleanup levels for non-UST-contaminated soil.

Acetone, 2-butanone, and methylene chloride were the only VOCs detected; however, their concentrations did not exceed RBCs. In addition, they are common laboratory contaminants. The pesticides 4,4'-DDD; 4,4'-DDE; and 4,4'-DDT, and the herbicide 2,4-DB, also were detected but at concentrations less than RBCs.

5.2.5 Nature of Surface Water Contamination

Table 5-7 summarizes the surface water results.

5.2.5.1 Inorganic Contamination

Total aluminum was detected at concentrations ranging from 0.6 mg/L to 14 mg/L in three surface water samples. One background sample contained 0.6 mg/L total aluminum. The secondary MCL for aluminum is 0.2 mg/L. All three of the locations where aluminum was detected exceeded the secondary MCL.

Total barium was detected at concentrations ranging from 0.03 mg/L to 1.0 mg/L in all 14 surface water samples; the background sample contained 0.31 mg/L. Dissolved barium was detected in seven surface water samples, none of which exceeded the background concentration of 0.27 mg/L. The Corps-recommended background value for total barium in groundwater is 0.988 mg/L. The RBC for barium is 0.260 mg/L. One sample exceeded the background concentration for total barium. Two samples contained total barium at concentrations in excess of the RBC for barium, and one sample contained dissolved barium at a concentration that exceeds the RBC for barium.

Total iron was detected at concentrations ranging from 1.2 mg/L to 22 mg/L in all of the surface water samples. The background sample contained 7.5 mg/L iron. Dissolved iron was detected in two surface water samples, neither of which exceeded the background sample concentration of 5.2 mg/L. There is not an established RBC for iron; the Alaska Surface Water Quality Criterion for iron is 1 mg/L, and the secondary MCL is 0.3 mg/L. All surface water samples exceeded these criteria; one sample exceeded the background sample concentration.

Total manganese was detected at concentrations ranging from 0.05 mg/L to 1.2 mg/L in all surface water samples; the background sample contained 1.2 mg/L. Dissolved manganese was detected at concentrations ranging from 0.06 mg/L to 1.2 mg/L in three samples; the background sample contained 1.2 mg/L. While all samples exceeded the secondary MCL of 0.018 mg/L, none of the samples exceeded the background sample concentration.

Total zinc was detected at concentrations of 0.06 mg/L and 0.12 mg/L in two surface water samples. The background sample contained 0.06 mg/L. Dissolved zinc was detected at 0.06 mg/L in two surface water samples. The Alaska Surface Water Quality Criterion for zinc is 0.047 mg/L, the secondary MCL for zinc is 5 mg/L, and the RBC for zinc is 1.1 mg/L.

5.2.5.2 Organic Contamination

Bunker C-range organics were detected at concentrations of 0.3 mg/L and 0.6 mg/L in two surface water samples. These data should be viewed with caution because they may represent samples with high organic content and therefore interferes with petroleum detection and quantitation and may not be representative of petroleum hydrocarbon values.

Diesel No. 2 was detected at concentrations of 0.4 mg/L and 0.6 mg/L in two surface water samples. Gasoline was detected at 0.5 mg/L in one surface water sample.

5.2.6 Nature of Groundwater Contamination

Twenty-two groundwater samples were collected from wells in the vicinity of the Landfill.

5.2.6.1 Inorganic Results

The constituents detected in groundwater samples collected from the Landfill Source Area are listed in Table 5-8. Analytes were retained as COPCs if they exceeded background and/or RBCs, or MCLs. Water quality criteria are used as reference values in the discussion, but have not been used to select COPCs because the Alaska regulations have not been promulgated.

Total arsenic was detected in seven wells, at concentrations ranging from 0.006 to 0.110 mg/L. One background well contained 0.006 mg/L total arsenic. Dissolved arsenic was detected in six wells, at concentrations ranging from 0.006 to 0.074 mg/L. The background wells did not contain dissolved arsenic above the detection limit of 0.005 mg/L. The Corps-recommended background value for total arsenic in groundwater is 0.072 mg/L and 0.02 mg/L for dissolved arsenic. The RBC for arsenic is 0.038 μ g/L, and the MCL and water quality criterion are 0.05 mg/L. One location exceeded these concentrations.

Total barium was detected in 12 wells, at concentrations ranging from 0.12 to 1.1 mg/L; a background well contained 0.17 mg/L total barium. Dissolved barium was detected in 13 wells, at 0.03 to 0.55 mg/L. A background well contained dissolved barium at 0.11 mg/L. The Corps-recommended background value for total barium in groundwater is 0.988 mg/L, and 0.341 mg/L for dissolved barium. The RBC for barium is 0.260 mg/L. The MCL for barium is 2 mg/L; the barium water quality criterion is 1 mg/L. One location exceeded the background concentration for total barium. Three wells exceeded the back-

ground concentration for dissolved barium. Four wells exceeded the RBC for dissolved barium.

Fluoride was detected in nine groundwater wells, at concentrations ranging from 0.1 to 0.980 mg/L. The background sample contained fluoride at 0.1 mg/L. The RBC for fluoride is 0.220 mg/L, the MCL is 4.0 mg/L, and the water quality criterion is 2.4 mg/L. No samples exceeded the MCL, two wells exceeded the RBC, and eight wells exceeded the background concentration.

Total iron levels exceeded their secondary MCL of 0.3 mg/L in all the groundwater samples collected from the Landfill. No RBC is established for iron. The water quality criterion for iron is 1 mg/L. Iron concentrations ranged from 2.0 to 100 mg/L; background concentrations were 6.9 mg/L and 9.5 mg/L. Ten wells contained iron above the background concentration.

Total manganese was detected in all groundwater wells, at 0.52 to 5.8 mg/L. The background sample contained manganese at 0.6 mg/L. The RBC is 0.018 mg/L, and the State of Alaska secondary MCL is 0.05 mg/L. No water quality criterion exists for manganese. All samples exceeded the State of Alaska secondary MCL and the RBC. Eleven wells exceeded the background sample concentration of 0.6 mg/L.

Silica and sulfate exceeded background concentrations in 14 wells and 17 wells, respectively. Sulfate in one well was detected at the secondary MCL concentration of 250 mg/L.

Total zinc was detected in eight wells, and dissolved zinc was detected in two ground-water wells at levels less than the RBC of 1.1 mg/L and the State of Alaska secondary MCL of 5 mg/L, but exceeding the water quality criterion of 0.047 mg/L. Zinc was not detected in the background wells.

Inorganic COPCs in Landfill groundwater include arsenic, barium, fluoride, and manganese.

5.2.6.2 Organic Results

The off-site laboratory detected bunker C as No. 6 diesel in nine groundwater wells, at concentrations ranging from 0.2 to 1.7 mg/L. A background well contained bunker C at 0.11 mg/L. Gasoline was detected in five wells, at concentrations ranging from 0.11 to 0.14 mg/L. A background well contained 0.13 mg/L gasoline. TRPH was detected in two wells,

at 0.07 mg/L and 0.09 mg/L. Diesel was detected in one well, at 0.42 mg/L. DROs were detected in one well, at 0.12 mg/L.

Groundwater samples were analyzed for herbicides and pesticides/PCBs in the off-site laboratory; however, none were detected. Organic compounds detected in the Landfill groundwater samples are listed in Table 5-8.

Acetone and methylene chloride were each detected in five wells but were not detected at concentrations exceeding RBCs and are not considered to be COPCs. Furthermore, methylene chloride was associated with blank contamination.

Eleven chlorinated compounds were detected in the groundwater samples collected from the Landfill Source Area. Of these chlorinated compounds, chloroform was associated with blank contamination during the 1993 field sampling. Chloroform was not detected in any of the groundwater samples collected during the 1994 field sampling event.

The chlorinated compounds that exceeded RBCs and are COPCs are 1,1,2,2-tetrachloroethane; 1,1,2-trichloroethane; 1,2-dichloroethane; bromodichloromethane; chloroform; cis-1,2-dichloroethene; trans-1,2-dichloroethene; and vinyl chloride. A current RBC was not available for trichloroethene; however, detected concentrations of this analyte exceeded the MCL.

In addition to the chlorinated compounds, benzene was detected in two groundwater wells, at 3.3 μ g/L and 4.4 μ g/L. Neither sample exceeded the MCL or water quality criterion of 5 μ g/L; however, both samples exceeded the RBC of 0.36 μ g/L for benzene.

Bis(2-ethylhexyl)phthalate was detected in eight groundwater wells, at concentrations ranging from 8.9 to 620 μ g/L. The RBC for bis(2-ethylhexyl)phthalate is 4.8 μ g/L, and the MCL is 6 μ g/L. All samples exceeded the MCL and the RBC.

Organic analytes retained as COPCs in Landfill groundwater include fuels; 1,1,2,2-tetrachloroethane; 1,1,2-trichloroethane; 1,2-dichloroethane; bromodichloromethane; chloroform; cis-1,2-dichloroethene; trans-1,2-dichloroethene; trichloroethene; vinyl chloride; benzene; and bis(2-ethylhexyl)phthalate.

Tables 5-9 and 5-10 summarize the results of the 1994 sampling event. Table 5-11 compares the 1993 results of the chlorinated compounds and the VOCs of potential concern to the 1994 results. Table 5-12 represents the concentrations of VOCs of concern detected in groundwater from 1990 through 1994.

5.3 EXTENT OF CONTAMINATION AT LANDFILL

The extent of contamination at the Landfill Source Area is discussed in the following section. The determination of extent is based solely on the designated project laboratory samples defined in the Management Plan (E & E 1993). Although field laboratory results were obtained from soil samples, no detectable concentrations of TRPH or VOCs were identified to provide a guide for further sampling. Sample locations were, to some extent, adjusted in the field on the basis of obvious areas where contamination would likely accumulate (i.e., unvegetated drainages). Vegetation consisting of trees, brush, and tundra was a significant criterion regarding sampling locations. For example, the Landfill area used for refuse disposal and likely consisting of barium ash in the surface soil is relatively vegetation-free but is surrounded to the north, east, and west by thick vegetation. The Landfill Source Area also is vegetated to the south, except along River Road and areas cleared for soil remediation activities.

Table 5-13 presents a summary of the analytes exceeding background concentrations and those considered COPCs for each medium at the Landfill. An analyte is considered a COPC if it exceeds the RBC, an MCL, or other applicable state or federal regulations.

Groundwater contamination was determined from 1993 monitoring wells installed and sampled, along with existing wells around the Landfill. Following a review of 1993 analytical results and water level elevations, additional wells were installed west of the Landfill in 1994 and sampled in October 1994. Analytical data from these wells are presented in Table 5-14.

5.3.1 Extent of Ash Contamination

The ash layer covers the entire active sanitary Landfill. This cover is applied under an operating permit approved by the State of Alaska. The cover is depicted on Landfill figures by the 10- and 15-foot elevation contour lines surrounding the "Sanitary Landfill Area." However, because of heavy equipment traffic over the active Landfill surface, and the stockpiling of ash at the south end of the Landfill until ready for use, the presence of ash extends south to the fence at River Road.

The inorganic compounds, including the inorganic COPCs (barium, chromium, manganese, and vanadium) present in the ash cover of the Landfill appear to exist at similar concentrations throughout the cover and do not appear to have migrated to surrounding

surface soil, with some exceptions, addressed in the surface soil discussion (see Figures 5-32 to 5-35). However, a grid was not established for sampling, and it is possible that isolated hot-spots were not identified. Barium, which was identified in previous investigations as a COPC, was found at concentrations similar to those reported previously.

Ash is an inorganic residue that remains after coal has been burned under specified conditions and mostly comprises the compounds silicon, aluminum, iron, and calcium and minor amounts of the compounds magnesium, sodium, potassium, and titanium. Ash may vary considerably from original mineral matter, which is largely kaolinite, illite, montmorillonite, quartz, pyrites, and gypsum (Perry). The elevated inorganics concentrations in the ash are likely the result of these compounds being originally present in coal. In addition, manganese and vanadium have been detected at elevated concentrations throughout OU-4 and are believed to be a result of naturally high concentrations in the soil. These inorganics may be present at elevated concentrations in ash because of the mixing of soil and ash before placement on the Landfill.

The dioxin congeners detected in the ash samples are below risk-based levels in all except one location, ASH-4, collected from the central east side of the active area (see Figures 5-1 and 5-23). Concentrations of dioxins in this sample are five times higher than those found at the other locations. The presence of dioxin may have occurred from the combustion of chlorinated solvents at the power plant. Fuels combustion would not generate dioxins/furans, so the occurrence in ash would depend on the amount and frequency of chlorinated solvents used on the coal pile. Based on concentration levels detected and the location of the ash samples, it is believed that dioxin and furan congeners may be present in relatively isolated areas of the Landfill ash and are not widespread. The full extent of contamination cannot be determined with certainty because soil outside the Landfill ash cover was not analyzed for dioxins.

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5.3.2 Extent of Soil Contamination

Soil sampling was conducted at surface locations on the Landfill but not within the Landfill, where contaminant sources are likely. Surficial contamination was identified in the immediate active Landfill area. Although many inorganic and several organic compounds were detected in subsurface soil, only manganese was found in one sample, AP-6140, at concentrations exceeding background and RBCs.

5.3.2.1 Inorganic Contamination

Elevated aluminum and vanadium concentrations in surface soil occur mainly in the drainages from the Landfill to the southwest and the southeast (see Figure 5-32) and may have originated from the Landfill ash cover. However, barium, which was detected in elevated concentrations in Landfill ash, was not detected above background concentrations in the drainages from the Landfill, suggesting that the elevated aluminum and vanadium concentrations are the result of an accumulation of these compounds from the naturally high concentrations in OU-4 soil.

A biased grab sample (SS-29) was collected from petroleum-stained soil immediately west of the Landfill. Elevated levels of barium, cadmium, chromium, copper, lead, mercury, and zinc were detected in this location, which appears to be an isolated hot-spot.

Another apparent hot-spot is a background location (SS-2) southwest of the Birch Hill Ski Lodge. Both barium and arsenic were detected at this location, above the Corps-recommended background levels. This sample was collected near a leaking UST. Contamination at this location is associated with the UST, not the Landfill.

Arsenic also was detected above the Corps-recommended background, at two locations south of River Road in the southwest drainage. Given the distance from the Landfill of these locations and the observation that arsenic was not detected above background in Landfill ash, this contamination is probably not attributable to surface runoff from the Landfill. The source of this contamination is more likely the result of other activities related to River Road. Lead was found at a concentration above the Corps-recommended background level, at a background location immediately adjacent to the Chena River. The source of this contamination is likely the result of activities on the Chena River, not the Landfill. Such activities might include motorboating with leaded gasoline, fishing with lead weights, and hunting with lead shot.

Elevated manganese concentrations are widespread and are assumed to be associated with naturally occurring elevated manganese concentrations in the soil, not to a particular source or practice.

5.3.2.2 Organic Contamination

Previous investigations detected VOCs in surface and near-surface soil. During the 1993 investigation, VOCs were detected infrequently in surface soil and at levels below RBCs.

TRPH and bunker C concentrations generally were detected in the same range for all samples. These data should be viewed with caution because they may represent samples with high organic content, which interferes with the petroleum detection and quantitation and may not be representative of petroleum hydrocarbon values. Additionally, only surface soils on the Landfill and surface and subsurface soils downgradient of the Landfill were sampled. Soils within the Landfill, where petroleum contamination likely would be found as part of the waste stream, were not sampled. Grab sample SS-29, which was collected from an area immediately west of the Landfill with a noticeable petroleum appearance and odor, contained approximately 33% TRPH (dry weight basis; see Figure 5-35). Elevated concentrations of bunker C were detected at SS-29 and at AP-6136 in the southwest corner of the Landfill (20,600 mg/kg; dry weight basis). These concentrations of cleanup levels exceed the State of Alaska cleanup levels. Petroleum contamination on surface soils appears to be limited to the biased sampling location, a stained area documented during a previous investigation (E & E 1991).

Elevated petroleum concentrations were detected in background location AP-6131, at 12 feet BGS. It was discovered at the end of the investigation that this background location was downgradient of a leaking gasoline UST adjacent to the Ski Lodge.

Elevated concentrations of 4,4'-DDT and 4,4'-DDE occurred in surface soil samples, mainly in the drainages to the Chena River. One upgradient location southeast of the Landfill also had concentrations of 4,4'-DDT above the RBC. Two locations, just north of River Road in the southwest drainage, contained levels of dieldrin above the RBC (see Figure 5-34). This type of pesticide contamination is consistent with basewide pesticide levels and is not considered to be a result of past or present practices at the Landfill. Concentrations found in Landfill soil should be reconsidered after publication of the Corps' basewide study of pesticides in soil.

5.3.3 Extent of Sediment Contamination

5.3.3.1 Inorganic Contamination

Barium exceeded background concentrations in two locations. SD-15, an upgradient location north of the Landfill at the base of Birch Hill (see Figures 5-1 and 5-32) and SD-2 contained barium at concentrations of 567 mg/kg, which exceeded the background concentration and RBC. SD-2 was collected from a pond north of the active Landfill and may be the recipient of runoff from the active portion of the Landfill.

Manganese exceeded background concentrations in six samples. Three of the samples were from one sediment location collected at three different depths. Sample SD-2, located northwest of the active Landfill, contained manganese concentrations exceeding the collected background sample concentration of 410 mg/kg at 0 to 6 inches (577 mg/kg) at 2.5 feet BGS (1,077 mg/kg) and at 5 feet BGS (415 mg/kg). At SD-1 (5 feet BGS), manganese was detected at concentrations of 518 mg/kg. Samples collected from the upstream Chena River locations (SD-13 and SD-14) contained manganese at concentrations of 426 mg/kg and 493 mg/kg, respectively.

Elevated inorganic constituents in Landfill sediments probably are due to naturally occurring concentrations; however, the pond and marsh area north of the active Landfill likely receives surface water runoff from the ash cover.

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5.3.3.2 Organic Contamination

TRPH and bunker C were generally widespread. The highest concentration of bunker C-range organic compounds at 4,060 mg/kg was found at the background location SD-16, which exceeds the State of Alaska cleanup levels. This sample also contained the highest TOC content of 26.7%. Most of the sediments contained organic carbon content in the range of approximately 17,000 to 40,000 mg/kg, which is 1.7% to 4.0%. The organic content of the samples should be considered when viewing these data because the petroleum detected in the samples may be due to the natural TOC of the samples, not to petroleum products.

5.3.4. Extent of Surface Water Contamination

5.3.4.1 Inorganic Contamination

Inorganic COPCs detected above background concentrations and/or RBCs appear to be limited mainly to the wetland area east of the active landfill (location SD-3). This area

may receive surface water runoff from the active landfill area, thereby contributing to elevated inorganic constituents.

Total aluminum exceeded the background value at two locations: SD-3 (east of the active landfill) and SD-7 (the western gravel pit area south of River Road).

Total barium exceeded the Corps-recommended background value for groundwater at location SD-3. Location SD-3 also was the only location where total iron and total zinc exceeded the background sample concentrations.

Surface water location SD-8 contained dissolved zinc at 0.7 mg/L, which exceeds the background sample concentration (0.6 mg/L) for dissolved zinc. Location SD-8 is at the eastern gravel pit area south of River Road.

5.3.4.2 Organic Contamination

Petroleum concentrations were detected at three locations: SD-1, SD-2, and SD-3. These areas are wetland areas to the north (SD-1 and SD-2) and east (SD-3) of the active landfill. These areas likely receive surface water runoff from the active landfill, thereby possibly contributing to elevated petroleum levels.

Bunker C-range organics were detected at the northern wetland area (SD-1 and SD-2). Diesel also was detected at SD-1.

Diesel and gasoline were detected at the SD-3 location, a possible "hot spot" because slightly elevated inorganic concentrations also were detected at this location.

5.3.5 Extent of Groundwater Contamination

5.3.5.1 Inorganic Contamination

Inorganic COPCs were detected in concentrations above background and/or RBCs in no apparent geographic pattern. They appeared to be associated with constituents that occur naturally at elevated concentrations in the soil.

Total arsenic in groundwater was below the MCL of 0.05 mg/L and the Corps-recommended background value of 0.072 mg/L at all locations except AP-6139, which was 0.11 mg/L (see Figure 5-36).

Total barium exceeded the background value at AP-5588. Four other wells in the southwest area exceeded RBCs, as well as one location south of River Road. None of the samples exceeded the MCL of 2.0 mg/L.

The highest concentration of fluoride was detected in AP-6138 at 0.98 mg/L, which exceeds the RBC of 0.220 mg/L. Two other locations also exceeded the RBC (AP-6131 and AP-6133); however, no apparent fluoride plume exists. None of the groundwater contained fluoride above the maximum contaminant level of 4.0 mg/L.

Elevated levels of manganese were present in all groundwater samples collected from the Landfill Source Area, in concentrations exceeding 1.0 mg/L at wells in the southwest area of the Landfill and in one well south of River Road. All samples exceeded secondary MCLs and RBCs.

5.3.5.2 Organic Contamination

As in previous investigations, groundwater contamination at the Landfill is at the head of the southwest drainage. The highest concentrations of VOCs were detected in wells AP-5588 and AP-5589, which contained 1,1,2,2-tetrachloroethane at concentrations of 1300 μ g/L and 6.3 μ g/L, respectively, exceeding the RBC 0.052 μ g/L. 1,2-Dichloroethane was detected at concentrations of 3.3 μ g/L and 5.1 μ g/L, respectively. Vinyl chloride was detected at concentrations of 1.0 μ g/L and 1.3 μ g/L, respectively. Benzene was detected at concentrations of 3.3 μ g/L and 4.4 μ g/L, respectively. These compounds were not detected in any other wells. Table 5-12 summarizes the VOCs detected in these two wells from 1990 through 1994. Figure 5-37 depicts the well locations where organic compounds exceeded their respective RBCs in groundwater.

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In 1993, tetrachloroethene was detected at a concentration of 1.4 μ g/L, and 1,1,2-trichloroethane at 8.1 μ g/L was detected only in well AP-5588. In 1994, tetrachloroethene was not detected in AP-5588 or any well sampled but 1,1,2-trichloroethane was detected at an estimated concentration of 9.9 μ g/L.

Trichloroethene; trans-1,2-dichloroethene; and cis-1,2-dichloroethene also were detected in wells AP-5588, AP-5589, and AP-6137. These compounds were detected again in all three wells in 1994.

In 1993, chloroform was detected in four wells (AP-6137 and AP-6138 in the southwest area, AP-6133 to the east of the Landfill, and AP-6131 to the north adjacent to the Ski Lodge). None of these samples exceeded the MCL of 100 μ g/L. The highest concentration detected was 33.0 μ g/L at well AP-6138. No chloroform was detected in AP-6138 or AP-6137 in 1994. The wells that previously contained chloroform (AP-6131 and AP-6133)

were frozen and could not be sampled. The detection limit of 2.6 μ g/L was slightly higher in 1994 than the 2.5 μ g/L detected in AP-6137 in 1993.

Bromodichloromethane was detected in AP-6138 and AP-6133 in 1993. Bromodichloromethane was not detected in AP-6138 in 1994. Well AP-6133 was not sampled in 1994.

Bis(2-ethylhexyl)phthalate was detected in seven wells. AP-6136 contained this compound at approximately 10 times the concentration found in the other wells and 100 times the MCL. Samples collected in 1994 were not analyzed for bis(2-ethylhexyl)phthalate.

Chlorinated compounds are present at elevated concentrations in the southwest permafrost-free area of the Landfill, which is consistent with past investigations. Most of these compounds are heavier than water and are considered denser-than-water, nonaqueous phase liquids (DNAPLs). DNAPL migration is discussed in more detail in Section 8, but based on detected concentrations and water solubilities, free-phase chlorinated hydrocarbons may not exist. Chloroform, found in several wells, may be due to field and/or laboratory contamination because it was not detected in two of the four wells resampled in 1994. Bis(2-ethylhexyl)phthalate was also at elevated concentrations in the wells in the southwest area. All the wells in this southwest permafrost-free area are completed at depths less than 100 feet; the depth to which these detected compounds extends is unknown. Additional wells were completed in the southwest area during the late 1994 field season, and analytical results indicate no chlorinated hydrocarbon contamination.

5.4 CHEMICAL-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO-BE-CONSIDERED CRITERIA

Chemical-specific ARARs/to-be-considered criteria (TBCs) for the Landfill are presented below. Action-specific ARARs will be presented in the OU-4 feasibility study. Location-specific ARARs were presented in Section 3.6.

A preliminary list of chemical-specific ARARs and TBCs was developed during preparation of the OU-4 Management Plan. Many substances identified initially were not detected in the most recent sampling events, and additional substances that had not been identified previously were detected. Tables 5-15 and 5-16 present an updated list of chemical-specific ARARs and TBCs for groundwater, soil, ash, and sediment.

Because the State of Alaska has been authorized formally to administer the drinking water program, the state MCLs are cited instead of the federal MCLs as ARARs for ground-

water (the federal and state MCLs are identical). In addition, the State of Alaska water standards were cited as TBCs. These include values from the water quality standards tables and from the Alaska Water Quality Standards Workbook (ADEC 1991b). EPA, Region 3, RBCs are identified as TBCs for groundwater constituents for which there are no primary MCLs. The RBC for groundwater represents either a risk of one person in 1 million developing cancer for carcinogens, or a hazard quotient of 0.1 for noncarcinogens.

No federal or state chemical-specific ARARs exist for soil; therefore, standards contained in state guidance documents are identified as TBCs. However, the State of Alaska Oil and Hazardous Substances Pollution Control Regulations (18 AAC 75) require that any person discharging a hazardous substance to land or waters must report it immediately to the state. In addition, the discharge must be cleaned up to the department's satisfaction. Eighteen AAC 75 provides the regulatory basis for the cleanup of non-UST-related contamination in soil and must be considered a TBC (ADEC 1991). This guidance states that soil contaminated by hazardous substances, other than crude oil or refined petroleum fuel products, must be cleaned to background levels or levels shown through leaching to not pose a risk to potential surface receptors. Also included as TBCs are EPA, Region 3, generated RBCs.

Table 5-1 LANDFILL MONITORING WELLS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Previous Investigations	Depth
AP-4382	9
AP-4383	15
AP-4384	13
AP-4387	14
AP-5424	49
AP-5430	9.5
AP-5580	24
AP-5581	19
AP-5582	29
AP-5583	29
AP-5584	25
AP-5585	27.5
AP-5586	34
AP-5587	29
AP-5588	29.5
AP-5589	69
AP-5590	19.5
AP-5591	29.5
AP-5593	31.5
AP-5594	54
AP-5595	84
AP-5597	9
AP-5599	9
AP-5601	4
AP-5602	10.5
FWLF-1	260
FWLF-2	28.5
FWLF-3	25.5
FWLF-4	24.7

Table 5-1 LANDFILL MONITORING WELLS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Previous Investigations	Depth
WLF-1	39
WLF-2	28.5
WLF-3	28.5
1993	
AP-6130	45
AP-6131	200
AP-6132	28
AP-6133	150
AP-6134	100
AP-6136	95
AP-6137	22
AP-6138	85
AP-6139	25
AP-6140	60
AP-6176	100
AP-6177	200
AP-6178	150
AP-6179	119
AP-6180	130
1994	
AP-6538	150.2
AP-6532	177.2
AP-6534	198.2

CORRELATION OF ASTM-D-2487 SOIL CLASSIFICATION AND GEOLOGIST'S FIELD CLASSIFICATION LANDFILL SOURCE AREA OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Well No. or Station No.	Sample No.	Depth (ft/bgs)	ASTM	Field Classification
001 A H	93LF001AH	0.5	SM	Ash
003 A H	93LF003AH	0.5	SM	Ash
00 5AH	93LF005AH	0.5	SM	Ash
007 A H	93LF007AH	0.5	SM	Ash
SS-3	93SL003SS	0.5	SP	SP
SS-16	93LF017SS	0.5	ML	SM
SS-22	93LF021SS	0.5	SM	SM
SD-3	93LF302SD	0.5	Peat	SP
AP-6163	93LF400SB	9.0	GM	GC/GM
AP-6136	93LF413SS	0.5	OL	ML/SM
AP-6179	93LF414SB	22.0	SP/SM	SP
AP-6176	93LF419SB	23.0	SM	SM
AP-6136	93LF422SB	14.0	SM	SP
AP-6136	93LF423SB	24.0	SP	GP

Key:

ASTM = American Society for Testing and Materials.

ft/bgs = Feet below ground surface.

GC/GM = Clayey gravel/silty gravel.

GP = Poorly graded gravel.

ML = Silt.

M/SM = Silt/silty sand.

OL = Organic silt.

SM = Silty sand.

SP = Poorly graded sand.

RISK-BASED CONCENTRATIONS AND BACKGROUND CONCENTRATIONS FOR ANALYTES DETECTED IN THE LANDFILL SOURCE AREA REMEDIAL INVESTIGATION OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

	Analytes Detected	d in Soils and Sec	liments		Analyte	s Detected in Surface	and Groundwat	er ^e
		Back	kground Concentra	ations			Background	Concentrations
Analyte	Risk-Based Concentration ^a (mg/kg)	Surface Soil ^b	Subsurface Soil ^c	Sediment ^d	Analyte	Risk-Based Concentration (µg/L)	Surface Water ^f	Groundwater ^g
Inorganics					Inorganics			
Aluminum	N/A	10,600-11,700	2,740-8,650	1,700-32,900	Arsenic	0.038	5U-22	72 ^h (total) 20 ^h (dissolved)
Arsenic	0.037	17 ^h	17 ^h	3U-38	Barium	260	80-270	998 ^h (total) 341 ^h (dissolved)
Barium	550	275 ^h	275 ^h	120-341	Calcium	N/A	99,000 ^k	50,000-52,000
Cadmium	3.9	1.7 ^h	1.7 ^h	2.8U-14U	Chloride	N/A	1,100-1,900	1,100
Calcium	N/A	3,710-6,870 ⁱ	2,030-6,140	497-23,100	Fluoride	220	100U-1,70 ^l	100
Chromium	39	35 ^h	35 ^h	3.6-14U	Iron	N/A	5,200 ^k	6,900-9,500
Cobalt	N/A	8.4-9.7	6U-10	7.1U-35U	Magnesium	N/A	50,000 ^k	16,000
Copper	290	16-23	8.8-24	14U-30	Manganese	18	1,200 ^k	570-600
Iron	N/A	20,600-21,300	8,320-20,900	6,640-12,100	Nitrate	5,800	30U-80 ^k	120-130

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Key at end of table.

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RISK-BASED CONCENTRATIONS AND BACKGROUND CONCENTRATIONS FOR ANALYTES DETECTED IN THE LANDFILL SOURCE AREA REMEDIAL INVESTIGATION OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

	Analytes Detected	d in Soils and Sec	liments		Analytes l	Detected in Surface	and Groundwat	er ^e
		Baci	ground Concentra	ations			Background	Concentrations
Analyte	Risk-Based Concentration ^a (mg/kg)	Surface Soil ^b	Subsurface Soil ^c	Sediment ^d	Analyte	Risk-Based Concentration (µg/L)	Surface Water ^f	Groundwater ^g
Lead	400	25 ^h	25 ^h	11-13	Orthophosphate	N/A	20U-450	30-110
Magnesium	N/A	5,260-6,040	1,530-4,880	511-4,260	Potassium	N/A	2,300 ^k	
Manganese	39	206-299 ⁱ	120-293	48-410	Silica	N/A	18,000 ^k	17,000
Mercury	2.3	0.1U	0.1U-0.2U	0.1U-0.7U	Sodium	N/A	13,000 ^k	5,600-5,700
Nickel	160	17-23	8.8-26	16-35U	Sulfate	N/A	69,000-170,000	16,000
Nitrate	13,000	N/A	N/A	N/A	Total Phosphorus	N/A	N/A	N/A
Nitrite	780	N/A	N/A	N/A	Zinc	1,100	50U-60 ^k	50U
Phosphorus	N/A	N/A	N/A	N/A	Organics			
Potassium	N/A	586-591 ⁱ	3.7-683	298-350U	1,1,2,2-Tetrachloroethane	0.052	N/A	N/A
Silver	39	0.1U	0.1	0.64-0.7U	1,1,2-Trichloroethane	0.19	N/A	N/A
Sodium	N/A	179-234	83-181	71U-350U	1,2-Dichloroethane	0.12	N/A	N/A
Vanadium	55	36	9-128	17-35U	Acetone	370	N/A	N/A
Zinc	2,300	35-57	16-60	35U-156	Benzene	0.36	N/A	N/A

RISK-BASED CONCENTRATIONS AND BACKGROUND CONCENTRATIONS FOR ANALYTES DETECTED IN THE LANDFILL SOURCE AREA REMEDIAL INVESTIGATION OPERABLE UNIT 4

FORT WAINWRIGHT, ALASKA

	Analytes Detected	d in Soils and Sec	liments		Analytes Detected in Surface and Groundwater ^e				
		Back	ground Concentr	ations			Background Concentration		
Analyte	Risk-Based Concentration ^a (mg/kg)	Surface Soil ^b	Subsurface Soil ^c	Sediment ^d	Analyte	Risk-Based Concentration (µg/L)	Surface Water ^f	Groundwater ^g	
Organics					bis(2-ethylhexyl)Phthalate	4.8	N/A	N/A	
1,2,3,4,6,7,8,9-OCDD	0.00041	N/A	N/A	N/A	Bromodichloromethane	0.17	N/A	N/A	
1,2,3,4,6,7,8,9-OCDF	0.00041	N/A	N/A	N/A	Chloroform	0.15	N/A	N/A	
1,2,3,4,6,7,8-HpCDD	0.000041	N/A	N/A	N/A	cis-1,2-Dichloroethene	6.1	N/A	N/A	
1,2,3,4,6,7,8-HpCDF	0.000041	N/A	N/A	N/A	Dichlorodifluoromethane	39	N/A	N/A	
1,1,1-Trichloroethane	N/A	N/A	N/A	N/A	Tetrachloroethene	6.1	N/A	N/A	
2,4-DB	63	N/A	N/A	N/A	trans-1,2-Dichloroethene	12	N/A	N/A	
2-Butanone	4,700	N/A	N/A	N/A	trichloroethene	N/A	N/A	N/A	
4,4'-DDD	0.27	N/A	N/A	N/A	Vinyl chloride	0.019	N/A	N/A	
4,4'-DDE	0.19	N/A	N/A	N/A	m & p-Xylene	52	N/A	N/A	
4,4'-DDT	0.19	N/A	N/A	N/A					
Acetone	780	N/A	N/A	N/A					
bis(2-ethylhexyl)Phthalate	4.6	N/A	N/A	N/A					
Dichloroprop	N/A	N/A	N/A	N/A					
Dieldrin	0.004	N/A	N/A	N/A				sa Mgas Kaliffi si	

RISK-BASED CONCENTRATIONS AND BACKGROUND CONCENTRATIONS FOR ANALYTES DETECTED IN THE LANDFILL SOURCE AREA REMEDIAL INVESTIGATION OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

	Analytes Detected	d in Soils and Se	diments		Analytes Detected in Surface and Groundwater ^e				
	Background Concentrations					Background	Concentrations		
Analyte	Risk-Based Concentration ^a (mg/kg)	Surface Soil ^b	Subsurface Soil ^c	Sediment ^d	Analyte	Risk-Based Concentration (µg/L)	Surface Water ^f	Groundwater ^g	
Endrin	2.3	N/A	N/A	N/A					
Methylene chloride	8.5	N/A	N/A	N/A					
Pyrene	230	N/A	N/A	N/A					
Trichloroethene	N/A	N/A	N/A	N/A					

- a United States Environmental Protection Agency, Region 3, Risk-Based Concentration Table, Third Quarter 1994, July 1994, cancer risk 10⁻⁷ or hazard quotient 0.1.
- b Background data from sample locations SS-1, and AP-6132, unless otherwise noted.
- ^C Background data from sample locations AP-6130, and AP-6132, unless otherwise noted.
- d Background data from sample locations SD-15 and SD-16.
- e Concentrations reported for metals are for total metals, unless otherwise noted.
- f Surface water background concentrations derived from sample locations SD-15 and SD-16, unless otherwise noted.
- g Groundwater background concentrations derived from sample locations AP-6132, unless otherwise noted.
- h Background data provided by the Corps.
- i Background data from sample locations SS-1, and AP-6132 only.
- k Background data from sample location SD-16 only.
- 1 Background data from sample location SD-15 only.

Key:

 $\mu g/L$ = Micrograms per liter.

SUMMARY OF ASH RESULTS LANDFILL SOURCE AREA OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA 1993

Analyte and Concentration Units	No. of Samples Analyzed/Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration	Risk-based Concentration ^a	Background Concentration ^b
Inorganic (mg/kg, dry weight)						
Aluminum	9/9	8,230-49,500	ASH-6	36,800		11,700
Arsenic	9/9	5-14	ASH-5	7.93	0.037	17°
Barium	9/8	92-3,130	ASH-6	2,050	550	275 ^c
Calcium	9/9	6,590-11,600	ASH-6	64,800	_	6,870 ^d
Chromium	9/9	14-52	ASH-6	33.9	39	35 ^c
Cobalt	9/9	8.2-23	ASH-2	14.8	_	9.7
Copper	9/9	22-75	ASH-6	50	290	45
Iron	9/9	13,800-28,700	ASH-6	21,300	_	21,500
Lead	9/9	1.4-17	ASH-5	11.0	400	25 ^c
Magnesium	9/9	5,050-12,700	ASH-2	8,800		6,040
Manganese	9/9	196-522	ASH-6	361	39	299 ^d
Mercury	9/1	0.1	ASH-7	0.1	2.3	0.1
Nickel	9/9	19-40	ASH-5	27.6	160	23
Potassium	9/9	680-3,180	ASH-5	2,110	_	591 ^d
Silver	9/3	0.1-0.2	ASH-5	0.133	39	0.4 ^d
Sodium	9/9	351-2,540	ASH-6	1,160	_	234U
Vanadium	9/9	26-131	ASH-8	101	55	36



SUMMARY OF ASH RESULTS LANDFILL SOURCE AREA OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA 1993

Analyte and Concentration Units	No. of Samples Analyzed/Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration	Risk-based Concentration ^a	Background Concentration ^b
Zinc	9/9	6.9-47	ASH-4	17.3	2,300	179 ^d
Chlorinated Pesticides (µg/kg, d	ry weight)					
4,4'-DDD	9/1	12	ASH-7	_	270	NA
4,4'-DDE	9/2	10-25	ASH-1	17.5	. 190	NA
4,4'-DDT	9/4	7.2-95	ASH-4	43.6	190	NA
Dioxins/Furans (pg/g)						
Total TCDF	9/1	2.2	ASH-7	_		NA
1,2,3,4,6,7,8-HpCDF	9/2	5.4-10	ASH-4	7.7	41	NA
Total HpCDF	9/2	5.4-55	ASH-4	30.2	_	NA
1,2,3,4,6,7,8-HpCDD	9/9	5.3-53	ASH-4	15	41	NA
Total HpCDD	9/7	5.3-88	ASH-4	27.2	_	NA
OCDF	9/1	170	ASH-4	_	410	NA
OCDD	9/7	37-600	ASH-4	152	410	NA

NOTE: Highlighted areas indicate criteria used to determine whether analyte was a chemical of potential concern.

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- ^a United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Excess cancer risk = 10⁻⁷. Hazard quotient = 0.1.
- b Background data from sample locations SS-1, SS-2, AP-6131, and AP-6132, unless otherwise noted.
- ^C Background data provided by the Corps.
- d Background data from sample locations SS-1, SS-2, and AP-6132 only.

Key:

 $\mu g/kg = Micrograms per kilogram.$

mg/kg = Milligrams per kilogram.

NA = Not applicable.

pg/g = Picograms per gram.

			Surface Soil			Subsurface Soil						
Analyte/ Concentration Units	No. of Samples Analyzed ^a / Detected	Range of Detected Conc.	Location of Maximum Conc.	Mean Conc.	Risk- based Conc. ^a	Back- ground Conc. ^d	No. of Samples Analyzed ^a / Detected	Range of Detected Conc.	Location of Maximum Conc. (ft/bgs)	Mean Conc.	Risk- based Conc. ^a	Back- ground Conc.b
Inorganics (mg/kg)												
Aluminum	33/33	4,870-38,000	SS-7	11,978	_	11,700	17/17	2,740-12,348	AP-6140	5,732	_	8,650
Arsenic	33/33	1.2-21	SS-11	8	0.037	17 [¢]	17/17	1.6-10	AP-6130/ AP6140	4.4	0.037	17 ^c
Barium	33/33	1.5-559	SS-29	127.6	550	275 ^c	17/17	39-121	AP-6140	61.9	550	275 ^c
Cadmium	33/1	11	SS-29	-	3.9	1.7 ^c	17/0		_	_	3.9	1.7 ^c
Calcium	33/33	1,840-45,900	SS-7	6,521	_	6,870	17/17	1,130-8,085	AP-6140	3,456		6,140
Chromium	33/33	9-42	SS-29	21	39	35 ^c	17/17	4.9-26.5	AP-6140	13.1	39	35 ^c
Cobalt	33/32	5.3-16	AP-6137	10.4	_	9.7	17/17	5.6-12.6	AP-6140	11.4	_	10
Соррег	33/33	11-264	SS-29	35	290	23	17/17	6.8-36	AP-6178	15.5	290	24
Iron	33/33	9,850-30,900	SS-09	20,664	_	21,500	17/17	5,330-24,990	AP-6140	11,754	_	20,900
Lead	33/33	3-2,480	SS-29	86.2	400	25 ^c	17/17	2.4-10	AP-6140	4.74	400	25 ^c
Magnesium	33/33	3,250-9,420	SS-9	5,994	-	6,040	17/17	1,530-7,791	AP-6140	3,731	_	4,880
Manganese	33/33	107-530	SS-11	303.5	39	299	17/17	62-456	AP-6140	169	39	293
Mercury	33/1	0.2	SS-29	-	2.3	0.2U	17/0		_	_	2.3	0.2U
Nickel	33/33	13-38	SS-9	24.6	160	23	17/17	8.0-30.8	AP-6140	16.2	160	26

Surface Soil Subsurface Soil Location No. of No. of Location of Risk-Range of Back-Samples Range of Samples of Maximum Risk-Back-Analyte/ Analyzed^a/ Detected Maximum Mean based Analyzed^a/ **Detected** Conc. ground based Mean ground Conc.b **Concentration Units** Conc.a Conc.d Conc.a Detected Conc. Conc. Conc. Detected Conc. (ft/bgs) Conc. 849 406-1,830 SS-9 591 3.7-1,470 AP-6140 Potassium 33/33 17/17 511 683 Silver 33/4 0.1 - 0.3AP-6137 0.2 39 0.2U 17/20 0.1 AP-6130 39 0.1 33/33 30-513 SS-10 304.3 234 17/17 76-441 AP-6140 211 181 Sodium Vanadium 33/33 10-56 SS-9 35 55 36 17/17 9.0-40 AP-6140 20.1 55 28 33/33 1.0-1,180 SS-29 89.9 2,300 57 17/17 16-61.7 AP-6140 30.9 2.300 60 Zinc Volatile Organic Compound (µg/kg) SS-29 780,000 AP-6177 780,000 33/4 21-373 128 NA 17/13 23-1,510 345 NA Acetone 7.79 8,500 33/22 8.8-26 AP-6136 14.5 8,500 NA 17/18 5.5-9.4 AP-6138 NA Methylene chloride 33/1 7.3 SS-11 NA 17/0 NA 1.1.1-Trichloroethane 17/0 33/1 55 SS-7 NA Trichloroethene NA Semivolatile Organic Compounds (µg/kg) 43,500 SS-29 4,600 NA 17/0 4,600 NA 33/1 bis(2-Ethylhexyl)phthalate 230,000 230,000 35/1 9,470 SS-29 NA 17/0 NA Pyrene

	Surface Soil Subsurface Soil											
Analyte/ Concentration Units	No. of Samples Analyzed ^a / Detected	Range of Detected Conc.	Location of Maximum Conc.	Mean Conc.	Risk- based Conc. ^a	Back- ground Conc.d	No. of Samples Analyzed ^a / Detected	Range of Detected Conc.	Location of Maximum Conc. (ft/bgs)	Mean Conc.	Risk- based Conc. ^a	Back- ground Conc.b
Other (mg/kg)	-											
Nitrate	5/1	0.9	AP-6136		13,000	NA	6/0	_		_	13,000	NA
Nitrite	5/5	0.3-1.4	SS-22	0.9	780	NA	6/0	-	_	_	780	NA
Total phosphorus	5/5	294-1,070	AP-6136	534.6		NA	6/6	239-463	AP-6179	368	_	NA
Total organic carbon	33/33	845-52,600	SS-29	15,230	_	NA	17/17	343-7,750	AP-6177	2,674	_	NA
Chlorinated Pesticides (µg/kg)											
4,4'-DDD	33/13	3.1-180	SS-11	48.8	270	NA	17/0	_			270	NA
4,4'-DDE	33/14	3.4-191	SS-21	34.3	190	NA	17/0	-	_	_	190	NA
4,4'-DDT	33/16	4.0-692	SS-21	115	190	NA	17/0			_	190	NA
Dieldrin	33/4	7.1-99	SS-10	46.3	4	NA	17/0	_			4:	NA
Endrin	33/1	4.2	SS-21	4.2	2,300	NA	17/0		_		2,300	NA
Fuels (mg/kg)												
Bunker C-range organics	33/32	17-124,000	SS-29	4,629	_	NA	15/9	12-52	AP-6179	29		NA
Diesel-range organics	3/2	12-31	SS-16	21.5	_	NA	15/0	_		_	_	NA
Diesel	33/0	_	_	_	_	NA	15/1	25	AP-6178			NA

Key at end of table.

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			Surface Soil						Subsurface Soi	il		
Analyte/ Concentration Units	No. of Samples Analyzed ^a / Detected	Range of Detected Conc.	Location of Maximum Conc.	Mean Conc.	Risk- based Conc. ^a	Back- ground Conc.d	No. of Samples Analyzed ^a / Detected	Range of Detected Conc.	Location of Maximum Conc. (ft/bgs)	Mean Conc.	Risk- based Conc. ^a	Back- ground Conc. ^b
Kerosene	33/0	_	_	_		NA	15/1	12	AP-6136	_	_	NA
TRPH	33/29	14-326,000	SS-29	11,374	<u> </u>	NA	15/12	14-230	AP-6176	58	_	NA
Chlorinated Herbicides (mg/l	(g)											
Dichloroprop	33/1	4.3	SS-29	_		NA	20/0					NA

NOTE: Highlighted areas indicate criteria used to determine whether analyte was a chemical of potential concern.

Key:

- = Not analyzed.

Conc. = Concentration.

ft/bgs = Feet below ground surface.

mg/kg = Milligrams per kilogram.

 μ g/kg = Micrograms per kilogram. NA = Not applicable.

TRPH = Total recoverable petroleum hydrocarbons.

^a United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 10⁻⁷. Hazard quotient = 0.1.

b Background data from sample locations AP-6130 and AP-6132, unless otherwise noted.

^C Background data provided by the Corps.

d Background data from sample lcoations SS-1 and AP-6132.

SUMMARY OF SEDIMENT RESULTS LANDFILL SOURCE AREA OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA 1993

Analyte and Concentration Units	No. of Samples Analyzed ^a / Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration	Risk-based Concentration ^a	Background Concentration ^b
Inorganics (mg/kg, dry w	eight)					
Aluminum	24/24	1,700-32,900	SD-16	10,700	_	32,900
Arsenic	24/23	1.1-38	SD-15	7.31	0.037	38
Barium	24/24	50-1,040	SD-2	183	550	341
Calcium	24/24	497-162,000	SD-2	16,500	_	23,100
Chromium	24/23	3.6-28	SD-1/SD-4	17.6	39	3.6
Cobalt	24/12	5.9-14	SD-1	9.48	_	35 U
Copper	24/23	7.5-60	SD-2	24.3	290	30
Iron	24/24	6,640-30,500	SD-1	16,700	_	12,100
Lead	24/24	3.4-110	SD-2	14.6	400	13
Magnesium	24/24	511-8,080	SD-1	4,770	_	4,260
Manganese	24/24	48-1,070	SD-2	310	39	410
Mercury	24/4	0.1-0.6	SD-2	0.325	2.3	0.7 U
Nickel	24/23	1.0-32	SD-1	19.1	160	16
Potassium	24/23	298-1,080	SD-2	616	_	298
Selenium	24/1	5.1	SD-15		39	5.1
Silver	24/3	0.6-0.64	SD-15	0.613	39	0.64

SUMMARY OF SEDIMENT RESULTS LANDFILL SOURCE AREA OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA 1993

Analyte and Concentration Units	No. of Samples Analyzed ^a / Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration	Risk-based Concentration ^a	Background Concentration ^b
Sodium	24/24	78-457	SD-1	208	_	350 U
Vanadium	24/23	13-52	SD-2	28		17
Zinc	24/23	23-156	SD-15	64.9	2,300	156
Fuels (mg/kg)				_		
Bunker C-range organics	24/20	7.5-4,060	SD-16	366	_	NA
Diesel-range organics	24/2	8.2-8.3	SD-12	8.25	_	NA
ТПРН	24/10	26-374	SD-14	176.2	_	NA
Volatile Organic Compou	nds (μg/kg, dry wei	ght)				
Acetone	24/7	17-574	SD-1	165	780,000	NA
2-Butanone	24/2	110-160	SD-1	135	4,700,000	NA
Methylene Chloride	24/9	7.4-99	SD-16	22.5	8,500	NA
Chlorinated Pesticides (με	g/kg, dry weight)					
4,4'-DDD	24/6	13-260	SD-3	79.2	270	NA
4,4'-DDE	24/6	3.7-120	SD-3	28.8	190	NA
4,4'-DDT	24/7	4.2-100	SD-3	23.6	190	NA
Herbicides (μg/kg, dry we	eight)					
2,4-DB	24/1	0.094	SD-4		63,000	NA

SUMMARY OF SEDIMENT RESULTS LANDFILL SOURCE AREA OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA 1993

Analyte and Concentration Units	No. of Samples Analyzed ^a / Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration	Risk-based Concentration ^a	Background Concentration ^b
Other (mg/kg, dry basis)						
Nitrate, as Nitrogen	5/3	0.5-2.0	SD-3	0.45	13,000	NA
TOC	24/21	2,420-276,000	SD-16	34,400	_	NA

^a United States Environmental Protection Agency, Region 3, Risk-based Concventration Table, Fourth Quarter 1994, November 1994. Cancer risk = 10⁻⁷. Hazard quotient = 0.1.

b Background data from sample locations SD-15 and SD-16.

Key:

- = Not analyzed.

mg/kg = Milligrams per kilogram.

 $\mu g/kg = Micrograms per kilogram.$

NA = Not applicable.

TOC = Total organic carbon.

TRPH = Total recoverable petroleum hydrocarbons.

U =

SUMMARY OF SURFACE WATER RESULTS LANDFILL SOURCE AREA OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA 1993

Analyte and Concentration Units	No. Samples Analyzed ^a / Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration	Alaska Water Quality Criteria ^e MCL	Risk-based Concentration ^a	Background Concentration ^b
Total Metals (mg/L)							
Aluminum	14/3	0.6-14	SD-3	5.23	—/0.2 ^f	_	0.6
Barium	14/14	0.03-1.0	SD-3	0.143	1/2	0.26	0.31
Calcium	14/14	17-98	SD-16	34.4	-/-		98
Iron	14/14	1.2-22	SD-3	4.02	1/0.3 ^f		7.5
Magnesium	14/14	5.0-49	SD-16	12.8	-/-	-	49
Manganese	14/14	0.05-1.2	SD-15	0.319	-/0.05 ^f	0.018	1.2
Potassium	14/7	0.8-6.7	SD-3	2.96	-/-		3.8
Silica	14/13	1.0-18	SD-16	8.31	-/-	_	18 ^d
Sodium	14/11	1.6-12	SD-16	3.75	—/250 ^f	_	12
Zinc	14/2	0.06-0.12	SD-3	0.09	0.047 ^g /5 ^f	11	0.06
Alkalinity (total)	14/9	43/150	SD-2	68.6	<20/—		NA
Alkalinity (HCO ₃)	14/9	43-150	SD-2	68.6	_/_	_	NA
Chlorides	14/6	1.1-5.9	SD-7	2.68	—/250 ^f		1.9
Fluoride	14/8	0.10-0.17	SD-15, 9	0.14	2.4/4	0.22	0.17
Sulfate	14/13	1.6-170	SD-16	34.3	/250f		170

SUMMARY OF SURFACE WATER RESULTS LANDFILL SOURCE AREA OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA 1993

Analyte and Concentration Units	No. Samples Analyzed ^a / Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration	Alaska Water Quality Criteria ^e MCL	Risk-based Concentration ^a	Background Concentration ^b
Dissolved Metals (mg/L)							
Barium	14/7	0.04-0.27	SD-15	0.13	1 ⁿ /2	0.26	0.27
Calcium	14/3	26-99	SD-16	55.3	_/_	_	98
Iron	14/2	0.4-5.2	SD-16	2.65	1 ⁿ /0.3 ^f		5.2 ^d
Magnesium	14/3	7.1-50	SD-16	26.0	/	_	50 ^d
Manganese	14/3	0.06-1.2	SD-16	0.473	/0.05 ^f	.018	1.2 ^d
Potassium	14/3	2.2-5.6	SD-3	3.37	_/_	-	3.8
Sodium	14/3	1.9-13	SD-16	6.7	—/250 ^f	_	13 ^d
Zinc	14/2	0.06-0.07	SD-8	0.068	0.047 ^g /5 ^f	11	0.06
Other (mg/L)							
Nitrate as Nitrogen	14/9	0.08-0.30	SD-10	0.206	10/10	5.8	0.08
Nitrate/Nitrite as Nitrogen	14/9	0.07-0.30	SD-10	0.200	10/10	0.37	0.07
Orthophosphate	14/6	0.03-11	SD-3	1.93	_	<u>-</u>	0.45
Total phosphate	14/2	0.06-0.15	SD-1	0.105		<u></u>	
Total organic carbon	14/1	47	SD-1	_		_	_
Total dissolved solids	14/13	98-770	SD-16	20	. —/500 ^f		360

SUMMARY OF SURFACE WATER RESULTS LANDFILL SOURCE AREA OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA 1993

Analyte and Concentration Units	No. Samples Analyzed ² / Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration	Alaska Water Quality Criteria ^e MCL	Risk-based Concentration ^a	Background Concentration ^b
Volatile Organic Compoun	ds (μg/L)						
Acetone	14/1	4.0	SD-2		-/-	370	NA
Methylene chloride	14/9	1.1-1.4	SD-13	1.17	_/_	4.1	NA
Toluene	14/1	2.4	SD-15	_	/1,000	75	NA
m&p-Xylenes	14/1	1.8	SD-8	_	-/10,000	140	NA
Fuels (mg/L)							
Bunker C-range organics	14/2	0.3-0.6	SD-1	0.45	**************************************	_	NA
Diesel No. 2	14/2	0.4-0.6	SD-3	0.5			NA
Gasoline	14/1	0.5	SD-3				NA

NOTE: Highlighted areas indicate criteria used to determine whether analyte was a chemical of potential concern.

a United States Environmental Protection Agency, Region 3, risk-based concentration table, Fourth Quarter 1994, November 1994. Cancer risk = 10⁻⁶. Hazard quotient = 0.1.

b Surface water background concentrations derived from sample locations SD-15 and SD-16, unless otherwise noted.

^C Surface water background concentrations derived from sample location SD-15 only.

d Surface water background concentrations derived from sample location SD-16 only.

e 18 AAC 70 (surface water criteria)/18 AAC 80.070 (MCLs).

f Secondary MCL.

g Twenty-four hour average concentration for total metal.

h Criteria for total metal used.

Key:

- = Not analyzed.

 μ g/L = Micrograms per liter. mg/L = Milligrams per liter.

NA = Not applicable.

MCLs = Maximum concentration limits.

Analyte and Concentration Units	No. of Samples Analyzed ^a / Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Conc.b	Alaska Water Quality Criteria/MCL (18AAC80.070)	Risk-based Conc. ^a	Back- ground Conc. ^b
Total Metals (mg/L)							
Arsenic	20/9	0.006-0.11	AP-6139	0.027	0.05/0.05	0.000038	.072 ^d
Barium	20/13	0.17-1.1	AP-5588	0.336	1/2	0.26	0.988 ^d
Calcium	20/17	25-190	AP-6139	66.6	/		52
Chromium	20/5	0.03-0.04	AP-6137, AP- 6138, AP-5588	0.036	0.11	0.01	0.13d
Copper	20/6	0.03-0.07	AP-6137	0.045	e/l(s)	0.14	0.02 U
Iron	20/17	6.9-100	AP-6139	25.2	1/0.3(s)	-	9.5
Lead	20/12	0.003-0.023	AP-6137	0.0098	e	0.015	0.066 ^d
Magnesium	20/17	15-44	AP-5588	19.1	/	_	16
Manganese	20/17	0.52-5.8	AP-6139	1.17	/0.05(s)	0.018	0.6
Nickel	20/1	0.05	AP-5588	-	e/0.1	0.073	0.05 U
Potassium	15/12	0.98-11	AP-5588	5.44		_	_
Silica	20/19	15-34	AP-6138	22.9	/	_	17
Sodium	20/17	4.6-28	AP-6133	10.9	/250(s)		5.7
Zinc	20/8	0.05-0.12	AP-6138	0.08	0.047/5(s)	1.1	0.05 U

Analyte and Concentration Units	No. of Samples Analyzed ^a / Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Conc. ^b	Alaska Water Quality Criteria/MCL (18AAC80.070)	Risk-based Conc. ^a	Back- ground Conc. ^b
Dissolved Metals (mg/L)							
Arsenic	20/7	0.006-0.074	AP-6139	0.017	0.05/0.05	0.000038	0.02 ^d
Barium	20/15	0.11-0.55	AP-5589	0.195	1/2	0.26	0.341 ^d
Zinc	20/2	0.07-0.09	AP-6138	0.08	0.047/5(s)	1.1	0.05 U
General Water Parameters (r	ng/L)						
Alkalinity (Total)	20/20	20-370	AP-6139	177	<20/	-	170
Alkalinity (HCO ₃)	20/20	20-370	AP-6139	177	/	_	170
Biochemical oxygen demand	20/2	6-7	AP-6138	6.5		_	5 U
Chloride	20/19	1.1-46	AP-5588	9.43	/250(s)	_	1.1
Fluoride	20/11	0.10-0.98	AP-6138	0.287	2.4/4	0.22	0.1
Nitrate	20/12	0.04-0.13	AP-6132	0.074	10/10	5.8	0.13
Nitrate/Nitrite	20/12	0.04-0.15	AP-6133	0.079	10/10	0.37	0.13
Orthophosphate	20/19	0.03-0.66	WLF-03	0.243		_	0.11
Sulfate	20/20	4.2-250	AP-6139	67.8	/250(s)	_	1.6
Total dissolved solids	20/20	120-800	AP-6139	344	/500(s)	_	240
Total organic carbon	20/20	3.2-16	AP-6133	8.47	/	_	7
Total suspended solids	22/3	19-460	AP-5591	196	/		_

Analyte and Concentration Units	No. of Samples Analyzed ^a / Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Conc. ^b	Alaska Water Quality Criteria/MCL (18AAC80.070)	Risk-based Conc. ^a	Back- ground Conc. b
Volatile Organic Compounds	s (μg/L)						
Acetone	20/5	17-87	FWLF-03	43.6		370	` NA
Benzene	20/2	3.3-4.4	AP-5589	3.85	5/5	0.36	NA
Bromodichloromethane	20/2	1.7-2.9	AP-6138	2.3	11,000 ^c /100	0.17	NA
Chloroform	20/3	2.5-33	AP-6138	18.5	1,240/100	0.15	NA
Dichlorodifluoromethane	20/2	4.1-5.5	AP-5589	4.8	100 ^d /	39	NA
1,2-Dichloroethane	20/2	3.3-5.1	AP-5589	4.2	5/5	0.12	NA
cis-1,2-Dichloroethene	20/3	4.5-130	AP-5588	48.2	/70	6.1	NA
trans-1,2-Dichloroethene	20/3	2.0-40	AP-5588	14.9	/100	12	NA
Methylene chloride	20/5	1-1.7	FWLF-2	1.3	/5 .	4.1	NA
1,1,2,2-Tetrachloroethane	20/2	6.3-1300	AP-5588	653	2,400/	0.052	NA
Tetrachloroethene	20/1	1.4	AP-5588	_	840/5	6.1	NA
1,1,2-Trichloroethane	20/1	8.1	AP-5588	_	9,400/5	0.19	NA
Trichloroethene	20/3	3.6-170	AP-5588	59.4	5/5	_	NA
Vinyl chloride	20/2	1.0-1.3	AP-5589	1.15	2/2	0.019	NA
Semivolatile Organic Compo	unds (μg/L)						
Bis(2-ethylhexyl)phthalate	20/8	8.9-620	AP-6136	117	/6	4.8	NA

Analyte and Concentration Units	No. of Samples Analyzed ^a / Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Conc.b	Alaska Water Quality Criteria/MCL (18AAC80.070)	Risk-based Conc. ^a	Back- ground Conc. ^b
Fuels (mg/L)			т	 	r –		
Bunker C-range organics	20/11	0.11-1.7	AP-6138	0.506			NA
Diesel No. 2	20/1	0.42	AP-5589	_	/		NA
Gasoline	20/7	0.11-0.14	FWLF-04	0.12	/	_	NA
Diesel-range organics	2/2	0.12-0.12	WLF-03	0.12	/	_	NA
TRPH (oil and grease)	20/2	0.07-0.09	AP-6138	0.08	/_	_	NA

^a United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 10⁻⁶. Hazard quotient = 0.1.

b Groundwater background concentrations derived from sample location AP-6132, unless otherwise noted.

^C Value for halomethanes, Alaska Water Quality Standards Workbook.

d Groundwater background concentrations provided by the Corps.

e Criterion is hardness dependent.

Key:

- = Not analyzed.

Conc. = Concentration.

 $\mu g/L$ = Micrograms per liter.

mg/L = Milligrams per liter.

NA = Not applicable.

TRPH = Total recoverable petroleum hydrocarbons.

U =

Table 5-9

VOLATILE ORGANICS IN GROUNDWATER LANDFILL SOURCE AREA OPERABLE UNIT 4

FORT WAINWRIGHT, ALASKA 1994

 $(\mu g/L)$

<u></u>	μειτή											
Well Number	Benzene	Acetone	trans-1,2-DCE	cis-1,2-DCE	TCE							
Risk-based Conc.a	0.36	370	12	6.1	5 ^b							
AP-6134	<2.2	<16	<2.7	<2.8	<2.4							
AP-6137	3.3 J	<16	6.3 J	18 J	9.3 J							
AP-6137	3.8 J	<16	6.9 J	21 J	11 J							
AP-6139	<2.2	18 J	<2.7	<2.8	<2.4							
FWLF-4	2.9 J	<16	<2.7	<2.8	<2.4							
AP-6136	2.9 J	<16	<2.7	<2.8	<2.4							
FWLF-3	2.9 J	<16	<2.7	<2.8	<2.4							
AP-5591	2.9 J	<16	<2.7	<2.8	<2.4							
AP-6138	4.8 J	<16	<2.7	<2.8	<2.4							
AP-5588	4.5 J	<16	51	150	180							
AP-5588	4.4 J	<16	54	150	180							
AP-5589	6.3 J	<16	4.9 J	19 J	7.3 J							
Well Number	Methylene Chloride	1,1,2,2-TCA	Dichlorodi- fluoromethane	1,2-DCA	1,1,2-TCA							
Risk-based Conc.a	4.1	0.052	39	0.12	0.19							
WLF-01	7.1 J	<2.0	<3.2	<3.0	<2.2							
AP-5585	4 J	<2.0	<3.2	<3.0	<2.2							
AP-6137	<3.7	9.2 J	<3.2	.<3.0	<2.2							
AP-6137	<3.7	9.5 J	<3.2	<3.0	<2.2							
AP-6139	4.5 J	<2.0	<3.2	<3.0	<2.2							
AP-5588	<3.7	1000	14 J	4.5 J	9.9 J							
AP-5588	<3.7	1100	14 J	4.6 J	9.5 J							
AP-5589	5.7 J	5.9 J	15 J	5.1 J	<2.2							
Sample Number	2-Butanone											
		=										
Risk-based Conc. ^a	190				***							

United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 10⁻⁶. Hazard quotient = 0.1.
 MCL.

Key:

Conc. = Concentration.

J = Estimated concentration.

 $\mu g/L$ = Micrograms per liter.

MCL = Maximum contaminant level.

Table 5-10

1994 PETROLEUM HYDROCARBON RESULTS IN GROUNDWATER LANDFILL SOURCE AREA OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

(mg/L)

Well Number	Gasoline-Range Organics	Diesel-Range Organics
AP-6132	< 0.015	NA
AP-5594	< 0.015	0.14 B
AP-5593	< 0.015	0.12 B
AP-5593	< 0.015	0.14 B
WLF-01	< 0.015	0.11 B
WLF-02	< 0.015	0.18 B
WLF-03	<0.015	0.25 B
FWLF-2	< 0.015	0.22 B
AP-5585	< 0.015	0.20 B
AP-6134	< 0.015	0.14 B
AP-6137	<0.015	0.16 B
AP-6137	0.017	0.14 B
AP-6139	< 0.015	0.15 B
FWLF-4	< 0.015	0.18 B
AP-6136	< 0.015	0.37 B
FWLF-3	<0.015	0.32 B
AP-5591	< 0.015	0.31 B
AP-6138	< 0.015	0.17 B
AP-5588	0.26	0.25 B
AP-5588	0.24	0.20 B
AP-5589	<0.015	0.21 B

Key:

B = Analyte was detected in the laboratory method blanks. These data should be viewed with extreme caution.

mg/L = Milligrams per liter.

NA = Not analyzed. The sample was lost during extraction.

CHLORINATED COMPOUNDS AND VOLATILE COMPOUNDS OF POTENTIAL CONCERN 1993 VERSUS 1994 LANDFILL SOURCE AREA OPERABLE UNIT 4

FORT WAINWRIGHT, ALASKA

 $(\mu g/L)$

	A	P-5588	A	P-5589	AP-	6133	AP-	6131		AP-6138	A	AP-6137	
Volatile Organic of Concentrations	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994	Risk- based Conc. ^a
Chloroform	<1.0	<2.6	<1.0	<2.6	20.0	NS	1.5	NS	33.0	<21.6	2.5	<2.6	0.15
1,1,2,2-Tetrachloroethane	1,300	1,000	6.3	5.9 J	4.0	NS	<1.0	NS	<1.0	<2.0	<1.0	9.2 J	0.052
1,1,2-Trichloroethane	8.1	9.9 J	<1.0	<2.2	<1.0	NS	<1.0	NS	<1.0	<2.2	<1.0	<2.2	0.19
1,2-Dichloroethane	3.3	4.5 J	5.1	5.1 J	<1.0	NS	<1.0	NS	<1.0	<3.0	<1.0	<3.0	0.12
Bromodichloromethane	<1.0	<2.2	<1.0	<2.2	1.7	NS	<1.0	NS	2.9	2.2	<1.0	<2.2	0.17
Cis-1,2-Dichloroethene	130	150	10.0	19 J	<1.0	NS	<1.0	NS	<1.0	<2.8	4.5	18 J	6.1
Dichlorodifluoromethane	4.1	14 J	5.5	15 J	<1.0	NS	<1.0	NS	<1.0	<3.2	<1.0	<3.2	39
Trans-1,2-dichloroethene	40	51	2.6	4.9 J	<1.0	NS	<1.0	NS	<1.0	<2.7	2.0	6.3 J	12
Tetrachloroethene	1.4	<1.7	<1.0	<1.7	<1.0	NS	<1.0	NS	<1.0	<1.7	<1.0	<1.7	6.1
Trichloroethane	170	180	4.7	7.3 Ј	<1.0	NS	<1.0	NS	<1.0	<2.4	3.6	9.3 J	5 ^b
Vinyl chloride	1.3	<3.0	1.0	<3.0	<1.0	NS	<1.0	NS	<1.0	<3.0	<1.0	<3.0	0.019
Benzene	3.3	4.5 J	4.4	6.3 J	<1.0	NS	<1.0	NS	<1.0	4.8 J	<1.0	3.3 J	0.36

NOTE: Benzene also was detected at estimated concentrations in FWLF-04 (2.9 J µg/L), AP-6136 (2.9 J µg/L), FWFL-03 (2.9 J µg/L), and AP-5591 (2.9 J µg/L) in 1994.

^a United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 10⁻⁶. Hazard quotient = 0.1. b MCL.

Key:

Conc. = Concentration.

J = Estimated concentrations.

 $\mu g/L = Micrograms per liter.$

NS = Not sampled. AP-6133 and AP-6131 were frozen during the 1994 sampling event.

Table 5-12 VOLATILE ORGANIC COMPOUNDS OF CONCERN RESULTS FROM 1990 TO 1994 AP-5588 AND AP-5589 OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

 $(\mu g/L)$

Well	Contaminant	4/90 ^c	8/91	10/91	4/92	9/92	9/93	7/94		Risk- based Conc. ^a
AP-5588	Vinyl Chloride	ND	1.1	ND(5)	2.6	1.2	1.3	ND		0.019
	Carbon Disulfide	ND	0.1	ND(5)	ND(0.1)	ND(0.5)	NA	ND(3.0)		2.1
	1,2-Dichloroethene (total)	470	338.5	60	450	282	170	201		5.5
	1,1-Dichloroethane	ND	0.4	ND(5)	ND(0.1)	0.6	ND(1.0)	ND(3.0)		81
	Benzene	5	2.9	ND(5)	4.5	3.7	3.3	4.5	J	0.36
	1,2-Dichloroethane	ND	0.4	ND(5)	ND(0.1)	3.2	3.3	4.5	J	0.12
	Trichloroethene	250	224	220	240	210	170	180		5.0 ^b
	1,2-Dichloropropane	ND	2.7	ND(5)	ND(0.1)	ND(0.5)	ND(1.0)	ND(3.5)		0.16
	Toluene	ND	0.1	ND(5)	ND(0.1)	ND(0.5)	ND(1.0)	ND(2.0)		75
	1,1,2-Trichloroethane	ND	14	330	11.4	ND(0.5)	8.1	9.9	J	0.19
	Tetrachloroethene	ND	2.1	ND(5)	3.3	2.5	1.4	ND(1.7)		6.1
	Ethyl Benzene	ND	0.2	ND(5)	ND(0.1)	ND(0.5)	ND(1.0)	ND(1.6)		130
	Total Xylenes	ND	0.4	ND(5)	ND(0.1)	ND(0.5)	ND(1.0)	ND(6.5)		1,200
	1,1,2,2-Tetrachloroethane	ND	1,960	2,100	1,000	15,000	1,300	1,000	E	0.052
AP-5589	Vinyl Chloride	ND	1.9	ND(5)	3	1.5	1.0	ND(3.0)		0.019
	Carbon Disulfide	ND	0.2	ND(5)	ND(0.1)	ND(0.5)	NA	ND(5.8)		2.1
	1,2-Dichloroethene (total)	29	19.4	ND(5)	36.6	23.9	12.6	23.9	J	5.5
	Benzene	6	6.7	6.7	7.9	5.6	4.4	6.3	J	0.36
	1,2-Dichloroethane	ND	4.2	ND(5)	ND(0.1)	5.2	5.1	5.1	J	0.12
	Trichloroethene	7	5.6	5.8	7.5	5.3	4.7	7.3	J	5.0 ^b
	1,2-Dichloropropane	ND	0.4	ND(5)	ND(0.1)	ND(0.5)	ND(1.0)	ND(3.5)		0.16
	1,1,2,2-Tetrachloroethane	ND	1.0	ND(5)	ND(0.1)	1.8	6.3	5.9	J	0.052



^a United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 10⁻⁷. Hazard quotient = 0.1.

D MCI.

^C Detection limits are unavailable for this data set.

Key:

B =

Conc. = Concentration.

BOD = Biochemical oxygen demand.

DRO = Diesel-range organics.

GRO = Gasoline-range organics.

J = Estimated concentrations.

 $\mu g/L = Micrograms per liter.$

mg/L = Milligrams per liter.

MCL = Maximum contaminant level.

NA = Not applicable

ND = Not detected.

TRPH = Total recoverable petroleum hydrocarbons.

TOC = Total organic carbon.

TDS = Total dissolved solids.

Table 5-13

ANALYTES EXCEEDING BACKGROUND AND RISK-BASED CONCENTRATIONS/ARARS LANDFILL SOURCE AREA OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

		Exceeds Risk-Based Concentration and		
Analyte	Exceeds Background	Background ^a		
Aluminum	Ash, SS, SW, SB			
Arsenic	SS, GW	SS, GW		
Barium	Ash, SS, SD, SW, GW	Ash, SS, SD, GW		
Cadmium	SS	SS		
Cobalt	Ash, SS, SD, SB			
Copper	Ash, SS, SD, SB			
Chromium	Ash, SS, SD	Ash, SS		
Fluoride	GW	GW		
Lead	SS, SD	SS		
Manganese	Ash, SS, SD, GW, SB	Ash, SS, SD, GW, SB		
Mercury	SS, SD			
Nickel	Ash, SD, SS, SB			
Vanadium	Ash, SS, SD, SB	Ash, SS		
Zinc	SS, SW, GW, SB			
Organics				
1,1,1-Trichloroethane	SS			
1,1,2-Trichloroethane	GW	GW		
1,1,2,2-Tetrachloroethane	GW	GW		
1,2-Dichloroethane	GW	GW		
1,2,3,4,6,7,8,9-OCDD	Ash	Ash		
1,2,3,4,6,7,8-HpCDD	Ash	Ash		
1,2,3,4,6,7,8,9-OCDF	Ash			
1,2,3,4,6,7,8-HpCDF	Ash			
2-Butanone	SD			

ANALYTES EXCEEDING BACKGROUND AND RISK-BASED CONCENTRATIONS/ARARS LANDFILL SOURCE AREA OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Analyte	Exceeds Background	Exceeds Risk-Based Concentration and Background ^a		
2,4-D	SD			
4,4'-DDD	Ash, SS, SD	, , , , , , , , , , , , , , , , , , , ,		
4,4'-DDE	Ash, SS, SD	SS		
4,4'-DDT	Ash, SS, SD	SS		
Acetone	SS, SD, SW, GW, SB			
Benzene	GW	GW		
bis(2-Ethylhexyl)phthalate	SS, GW	SS, GW		
Bromodichloromethane	GW	GW		
Chloroform	GW	GW		
cis-1,2-Dichloroethene	GW	GW		
Dichlorodifluoromethane	GW			
Dichloroprop	SS			
Dieldrin	SS	SS		
Endrin	SS			
Iron	GW			
Methylene chloride	SS, SD, SW, GW, SB			
Potassium	GW			
Pyrene	SS			
Silica	GW			
Sulfate	GW			
Tetrachloroethene	GW			
Toluene	sw			
trans-1,2-Dichloroethene	GW	GW		
Trichloroethene	SS, GW	GW		
Vinyl chloride	GW	GW		

ANALYTES EXCEEDING BACKGROUND AND RISK-BASED CONCENTRATIONS/ARARS LANDFILL SOURCE AREA OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Analyte	Exceeds Background	Exceeds Risk-Based Concentration and Background ^a
m&p-Xylenes	SW	
Bunker C-range organics	SS, SD, SW, SB, GW	SS, SD, GW
Diesel No. 2	SW	sw
Diesel-range organics	SS, SD, GW	GW
Gasoline	SW, GW	GW, SW
TRPH	SS, SD, SB, GW	SS, GW

^a Petroleum-related contaminants in soil have been compared to the Alaska Department of Environmental Conservation cleanup matrix.

Key:

ARARs = Applicable or relevant and appropriate requirements.

GW = Groundwater.

SB = Subsurface soil.

SD = Sediment.

SS = Surface soil.

SW = Surface water.

TRPH = Total recoverable petroleum hydrocarbons.

Table 5-14 ADDITIONAL LANDFILL WELLS 1994 RESULTS FOR GROUNDWATER OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Well and Sample No:	MWP-8	MW-14	MWP-6D 94LF902GW	MWP-6D 94LF903GW	MWP-6D 94LF990GW
Volatile Organic Compound (με	g/L)				
Chloroform	<25	<5	9	<5	<5
Semivolatile Organic Compound	ds (μg/L)				
Di-n-butylphthalate	5 J	2 J	2 J,B	2 J,B	NA
bis-(2-Ethylhexyl)phthalate	17	47	42	1 J	NA
Petroleum Hydrocarbons (mg/L	<u>.)</u>				
DRO	320	<100	380	170	NA
GRO	<0.10	< 0.10	< 0.10	< 0.10	<0.10
Inorganics (mg/L)					
Calcium	30.0	21.5	41.3	40.2	NA <u>.</u>
Iron	10.4	10.7	4.1	4.1	NA
Magnesium	9.9	10.5	13.7	13.4	NA
Manganese	0.71	0.93	0.76	0.75	NA
Potassium	3.4	2.5	4.9	4.6	NA
Sodium	7.0	4.6	17.6	17.4	NA
Fluoride	0.18	0.17	0.26	0.31	NA
Chloride	0.10	1.1	11.4	12.9	NA
TRPH	0.45	0.25	0.93	0.63	NA
TOC	39.9	26.2	7.7	7.9	NA
BOD	120	<2.1	14.5	15.7	NA
Silica	1.0	12.1	19.3	20.2	NA
TDS	200	173	225	223	NA
Alkalinity	133	104	152	152	NA
Nitrate-N/Nitrite-N	0.037	0.030	0.029	0.023	NA

Key at end of table.

Key:

B =

Conc. = Concentration.

BOD = Biochemical oxygen demand.

DRO = Diesel-range organics.

GRO = Gasoline-range organics.

J = Estimated concentrations.

 $\mu g/L$ = Micrograms per liter.

mg/L = Milligrams per liter.

MCL = Maximum contaminant level.

NA = Not applicable

ND = Not detected.

TRPH = Total recoverable petroleum hydrocarbons.

TOC = Total organic carbon.

TDS = Total dissolved solids.

Table 5-15

CHEMICAL-SPECIFIC TBCs FOR SOIL/ASH/SEDIMENT LANDFILL SOURCE AREA OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Constituent	TBCs
Barium	(1) Background or contaminant leaching assessment(2) 550 mg/kg
Cadmium	(1) Background or contaminant leaching assessment (2) 3.9 mg/kg
Lead	(1) Background or contaminant leaching assessment (2) 400 mg/kg
Manganese	(1) Background or contaminant leaching assessment (2) 39 mg/kg
Vanadium	(1) Background or contaminant leaching assessment (2) 55 mg/kg
Arsenic	(1) Background or contaminant leaching assessment (2) 0.037 mg/kg
Chromium	(1) Background or contaminant leaching assessment (2) 39 mg/kg
Dieldrin	(1) Background or contaminant leaching assessment (2) 0.004 mg/kg
4,4'-DDT	(1) Background or contaminant leaching assessment
4,4'-DDE	(2) 0.19 mg/kg
1,2,3,4,6,7,8,9-OCDD	(1) Background or contaminant leaching assessment (2) 430 mg/kg
1,2,3,4,6,7,8-HpCDD	(1) Background or contaminant leaching assessment (2) 43 mg/kg
DRO	(3) 100-2,000 mg/kg
RRO	(3) 2,000 mg/kg

- (1) Interim Guidance for Non-UST Contaminated Soil Cleanup Levels, July 17, 1991. "Soils contaminated by hazardous substances other than crude oil or refined petroleum products must be cleaned to background levels or to levels shown through a contaminant leaching assessment to not lead to groundwater contamination through leaching nor pose a risk to potential surface receptors."
- (2) Risk-based concentrations equivalent to a cancer risk of 1E-07 or a hazard quotient of 0.1.
- (3) Interim Guidance for Non-UST Contaminated Soil Cleanup Levels, July 17, 1991. Matrix scoresheet.

Key:

DRO = Diesel-range organics.

mg/kg = Milligrams per kilogram.

RRO =

TBCs = To be considered criteria.

UST = Underground storage tank.

Table 5-16

CHEMICAL-SPECIFIC ARARS AND TBCs FOR GROUNDWATER LANDFILL AREA **OPERABLE UNIT 4** FORT WAINWRIGHT, ALASKA

mg/L

Constituent	State ARARs ²	TBCs
Arsenic	0.05 ^b	3.8X10 ^{-5c} 0.05(III) ^f , 0.48(V) ^f
Barium	2.0 ^a	0.26 ^{c/1.0} f
Fluoride	4.0 ^a	0.22 ^c /2.4 ^f
Manganese	0.05 ^b	0.018 ^c
1,1,2-Trichloroethane	0.005 ^a	0.00019 ^c /9.4 ^f
1,2-Dichloroethane	0.005 ^a	0.00012c/0.005 ^f
Benzene	0.005 ^a /0.01 ^e	0.00036 ^c /0.005 ^f
bis(2-ethylhexyl)phthalate	0.006 ^a	0.0048 ^c
Bromodichloromethane	0.1 ^d	0.00017 ^c /0.1 ^{d,f}
Chloroform	0.1 ^d	0.00015 ^c /1.24 ^f
cis-1,2-Dichloroethene	0.07 ^a	0.0061 ^c
Tetrachloroethene	0.005 ^a	0.0016 ^c /0.84 ^f
trans-1,2-Dichloroethene	0.1 ^a	0.012 ^c
Trichloroethene	0.005 ^a	0.005 ^f
Vinyl chloride	0.002ª	1.9 X 10 ⁻⁵ c/0.002 ^f
1,1,2,2-tetrachloroethane		0.000052 ^c /2.4 ^f
Fuels	_	Fail organoleptic tests; no visible sheen, film, or discoloration

^a 18 AAC 80.070(a) Primary Maximum Contaminant Levels.

Key:

AAC = Alaska Administrative Code.

ARARs = Applicable or relevant and appropriate requirements.

EPA =United States Environmental Protection Agency.

Micrograms per liter. $\mu g/L =$

mg/L = Milligrams per liter.

TBCs = To be considered criteria.

b 18 AAC 80.070(b) Secondary Maximum Contaminant Levels.

^C Risk-based concentrations equivalent to a cancer risk of 1E-06 or a hazard quotient of 0.1 (EPA 1994).

d This number applies to total trihalomethanes (the sum of the concentrations of bromodichloromethane, dibromochloromethane, tribromomethane, and chloroform).

e 18AAC70.020 protected water use classes, Alaska Water Quality Criteria, and Alaska Water Quality Standards Table. The value for total aromatic hydrocarbons, which includes benzene, toluene, ethylbenzene, and total xylenes (BTEX), is 10 μg/L. The value for total aqueous hydrocarbons, which includes BTEX, polynuclear, aromatic hydrocarbons (PAHs), and PAH alkyl homologues is 15 μ g/L. f Alaska Department of Environmental Conservation, 1991, Alaska Water Quality Standards Workbook.

CHENA

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PLATE

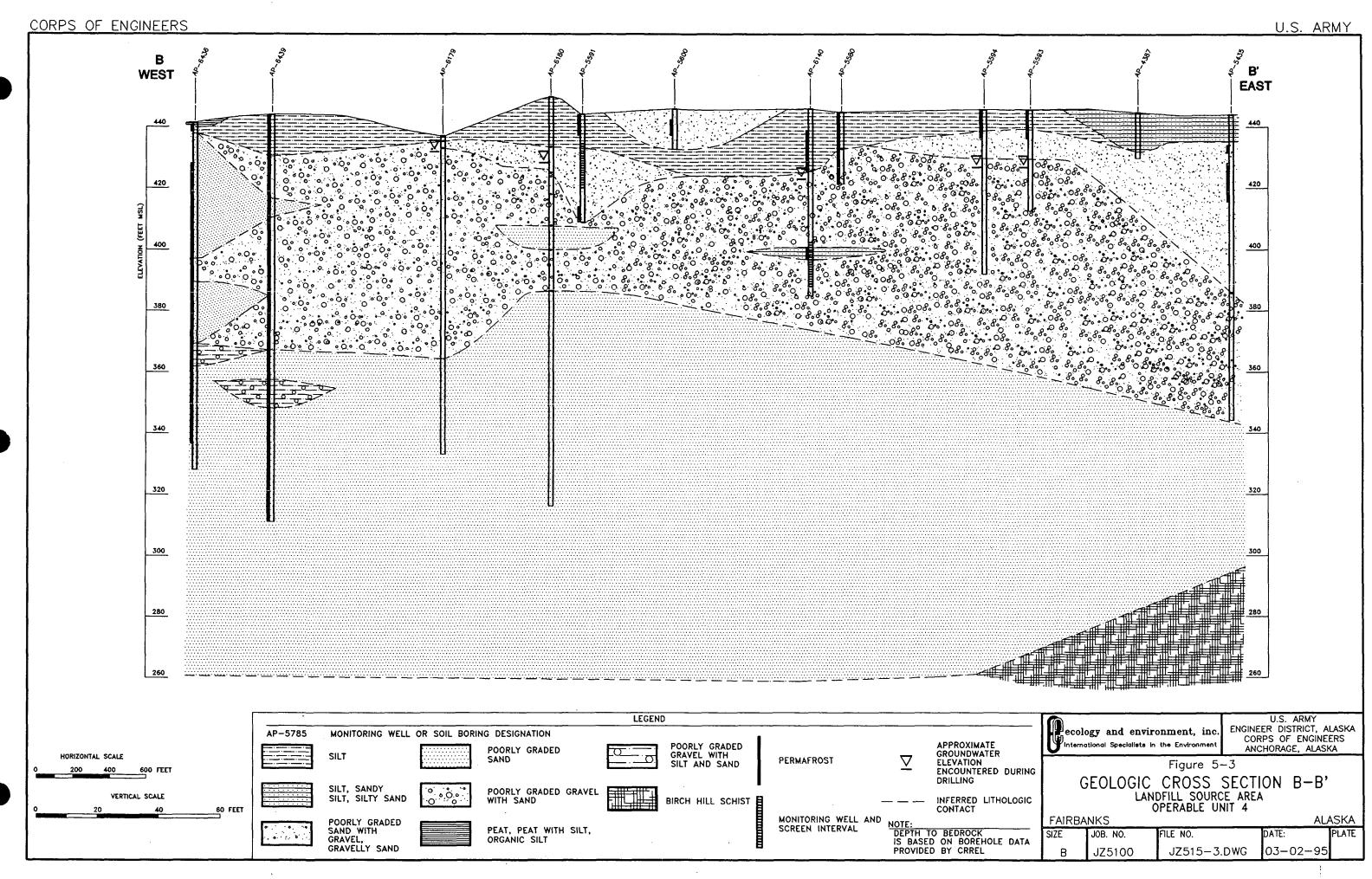
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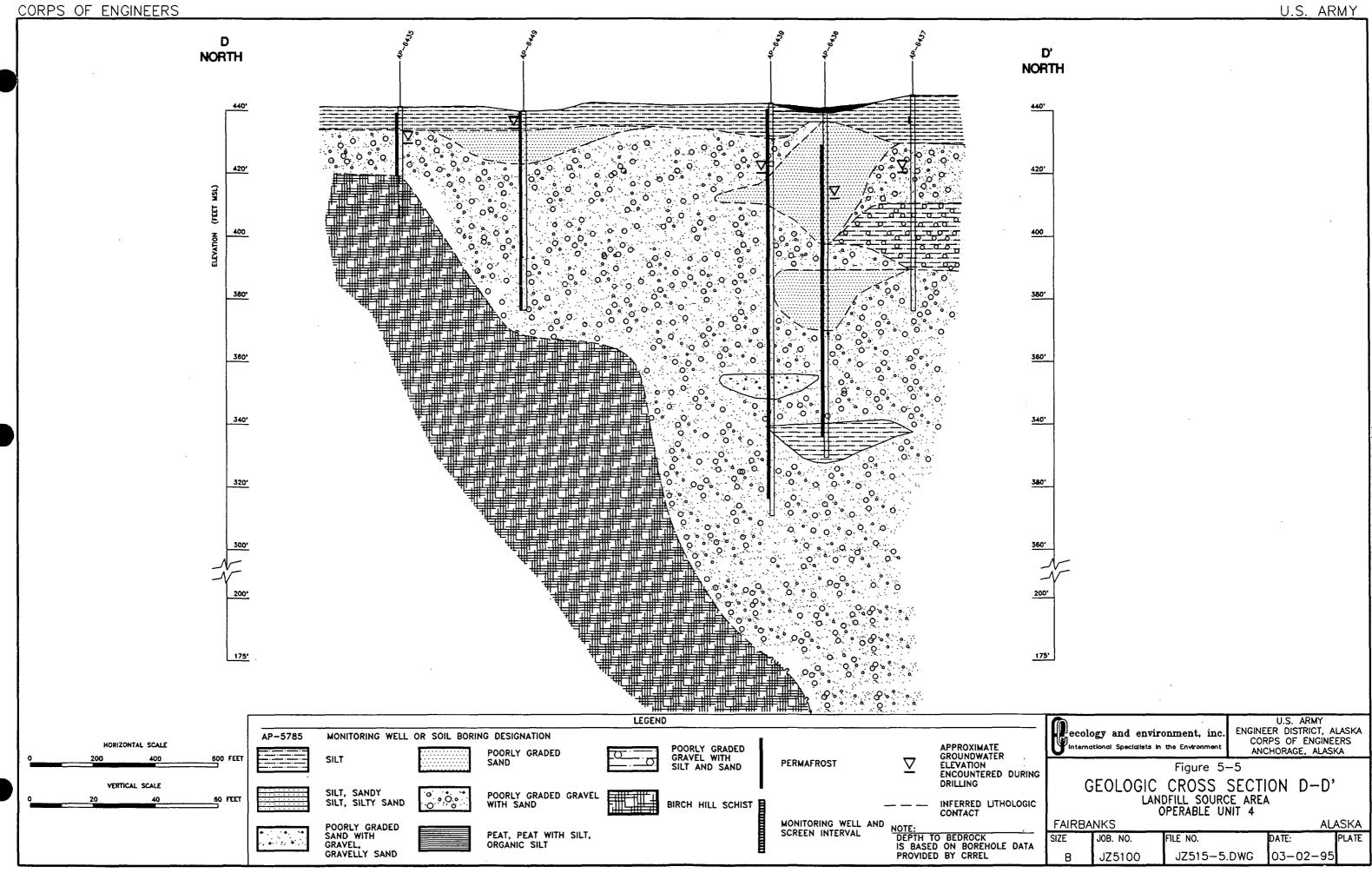
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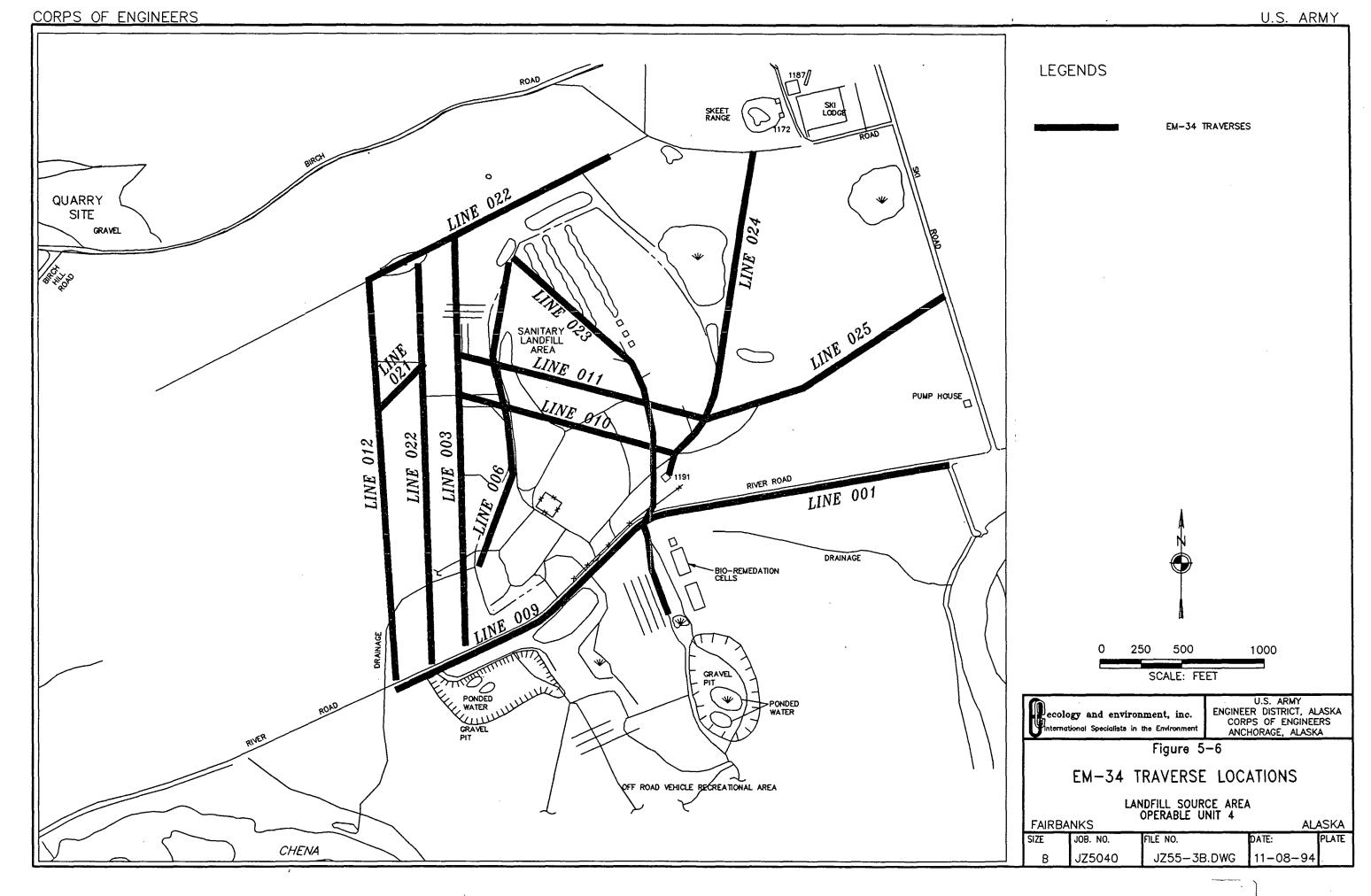
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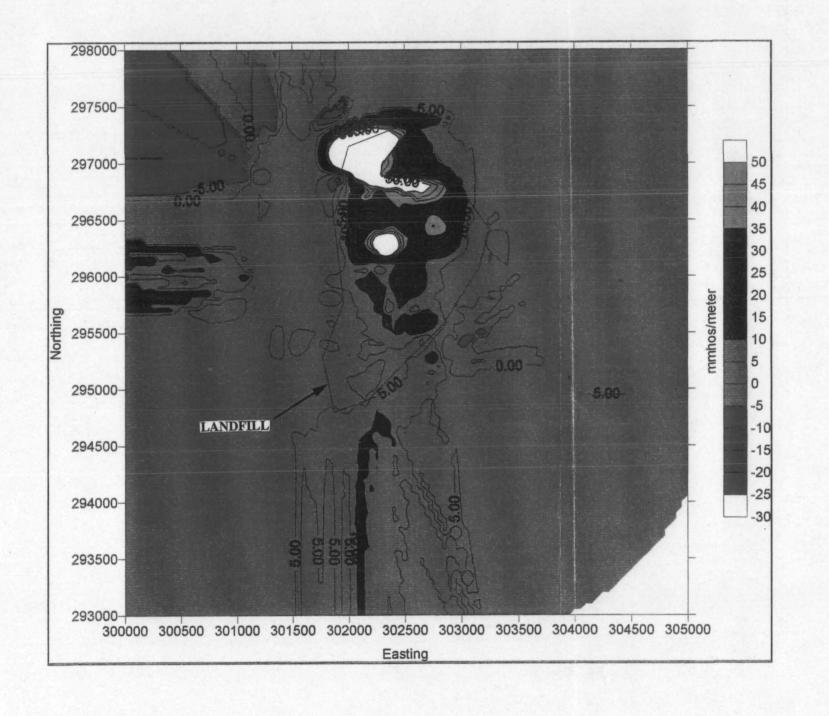
FILE NO.

JZ515-1.DWG











mmhos/meter contour interval 5 mmhos/meter

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ENGINEER DISTRICT, ALASKA
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

Figure 5-7 HORIZONTAL 20-METER EM-34 DATA LANDFILL SORCE AREA

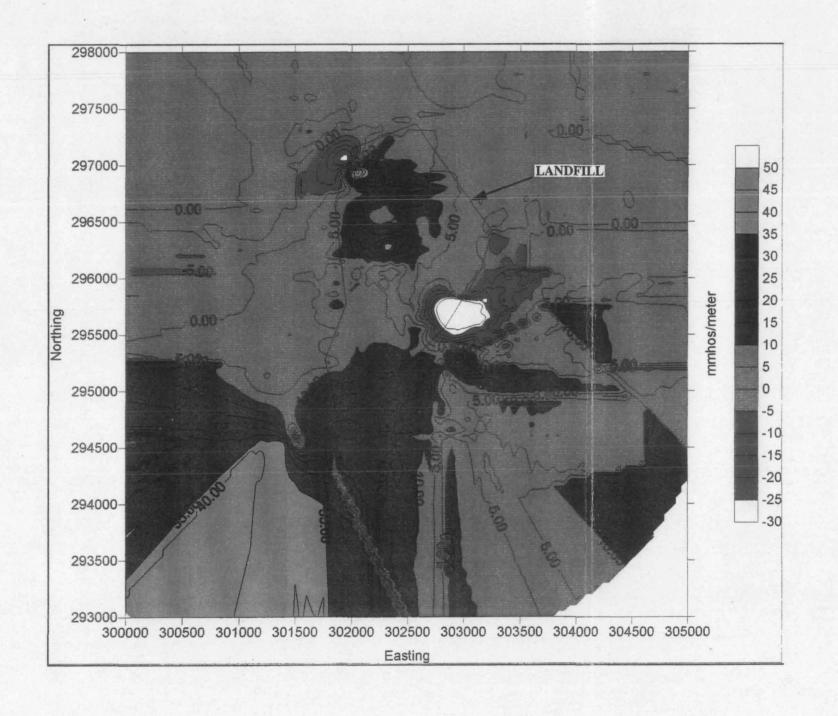
FORT WAINWRIGHT, OU-4

 FAIRBANKS
 ALASKA

 SIZE
 JOB. NO.
 FILE NO.
 DATE:
 PLATE

 A
 JZ5901
 94OCT24
 94OCT24

 DSGN.
 AES
 CHK.
 D.A.
 SHEET





mmhos/meter

contour interval 5 mmhos/meter

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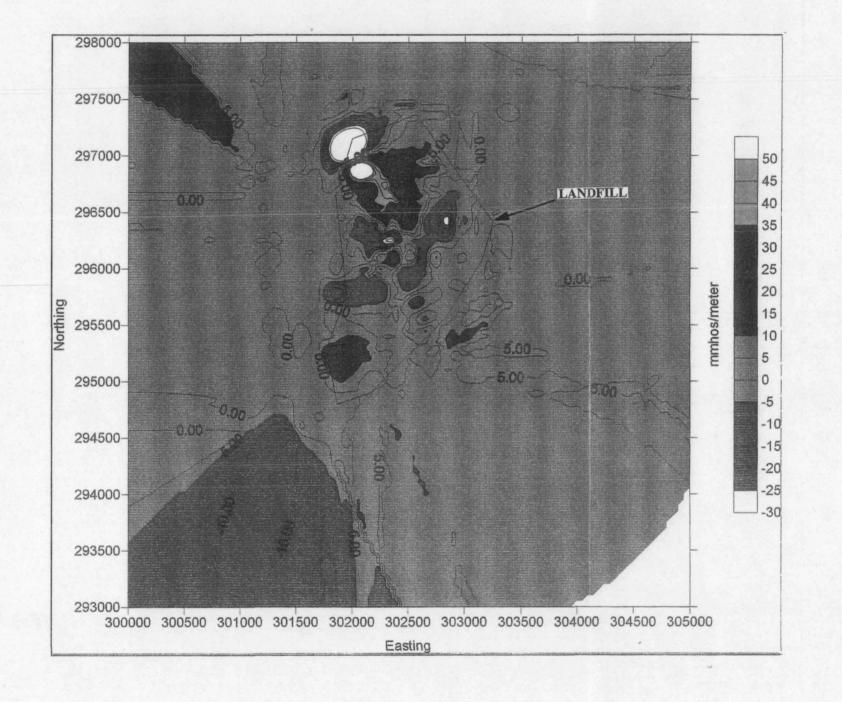
U.S. ARMY ENGINEER DISTRICT, ALASKA CORPS OF ENGINEERS ANCHORAGE, ALASKA

Figure 5-8 HORIZONTAL 40-METER EM-34 DATA

FORT WAINWRIGHT, OU-4

FAIRB	ANKS		ALASKA
SIZE	JOB. NO. JZ5901	FILE NO.	DATE: PLATE 940CT24
DSGN.	AES	CHK D.A.	SHEET

CORPS OF ENGINEERS





LEGEND

mmhos/meter contour interval 5 mmhos/meter

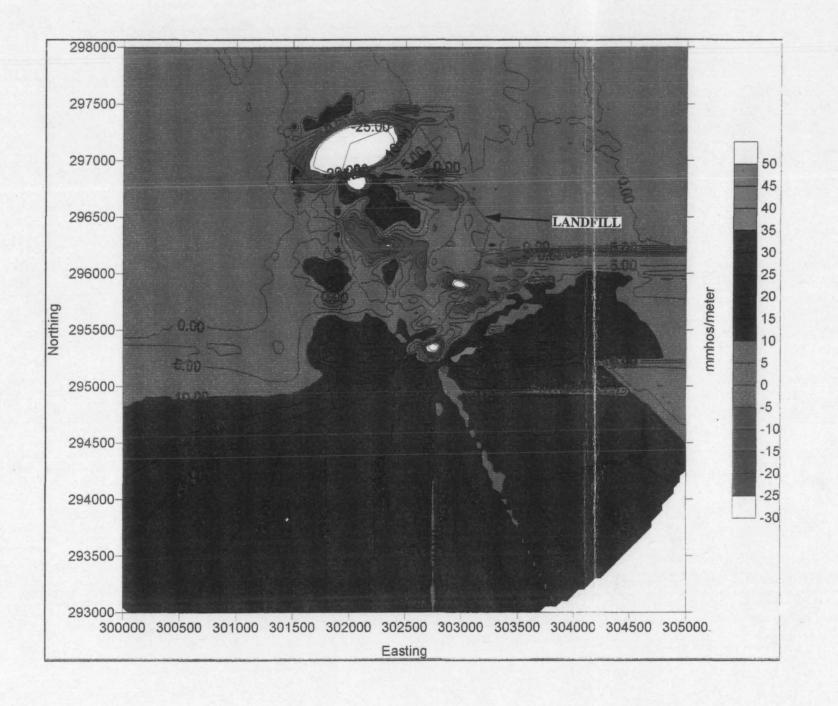
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ANCHORAGE, ALASKA

Figure 5-9
VERTICAL 20-METER EM-34 DATA
LANDFILL SORCE AREA

FORT WAINWRIGHT, OU-4

FAIRB	ANKS			ALASKA
SIZE	JOB. NO.	FILE NO.	DATE:	PLATE
A	JZ5901		94OCT24	
DSGN.	AES	CHK. D.A.	SHEET	1000





mmhos/meter

contour interval 5 mmhos/meter

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ENGINEER DISTRICT, ALASKA
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

Figure 5-10
VERTICAL 40-METER
EM-34 DATA

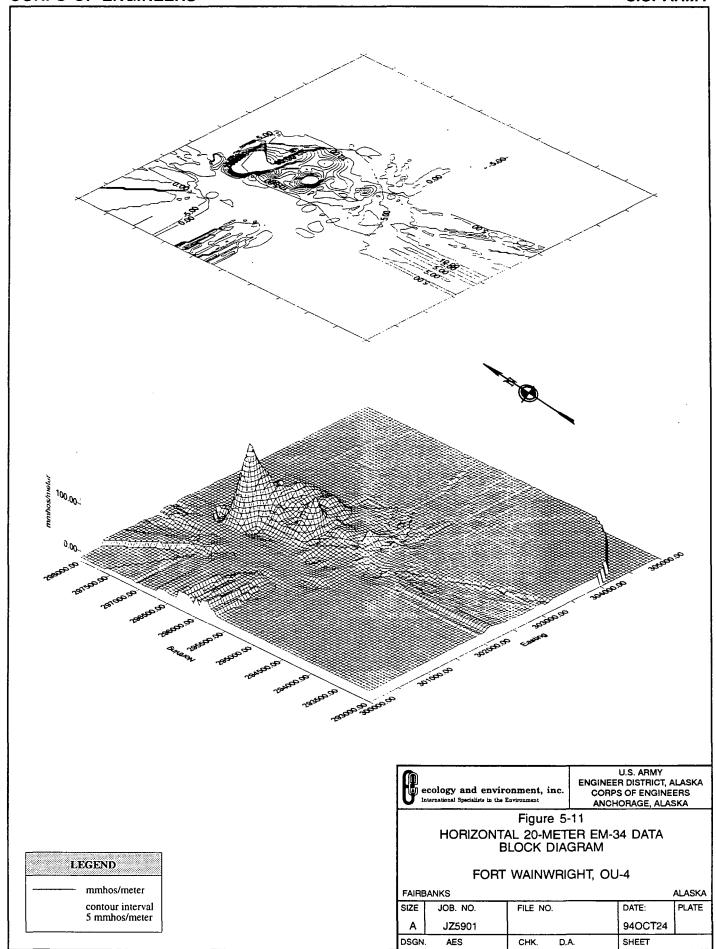
FORT WAINWRIGHT, OU-4

 FAIRBANKS
 ALASKA

 SIZE
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 94OCT24

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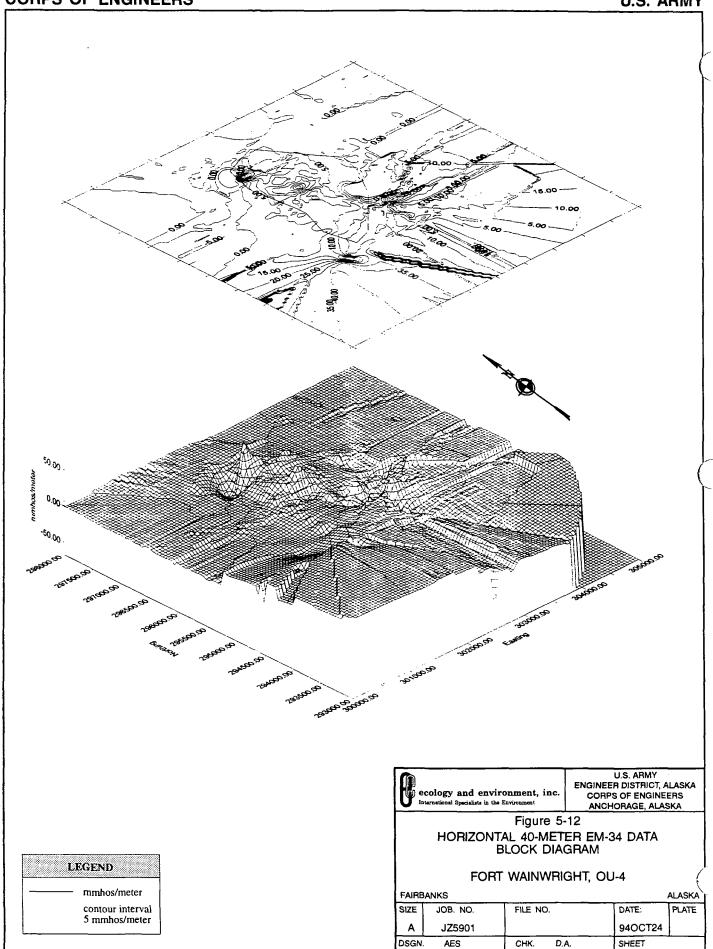


Figure 5-13

VERTICAL 20-METER EM-34 DATA BLOCK DIAGRAM

FORT WAINWRIGHT, OU-4

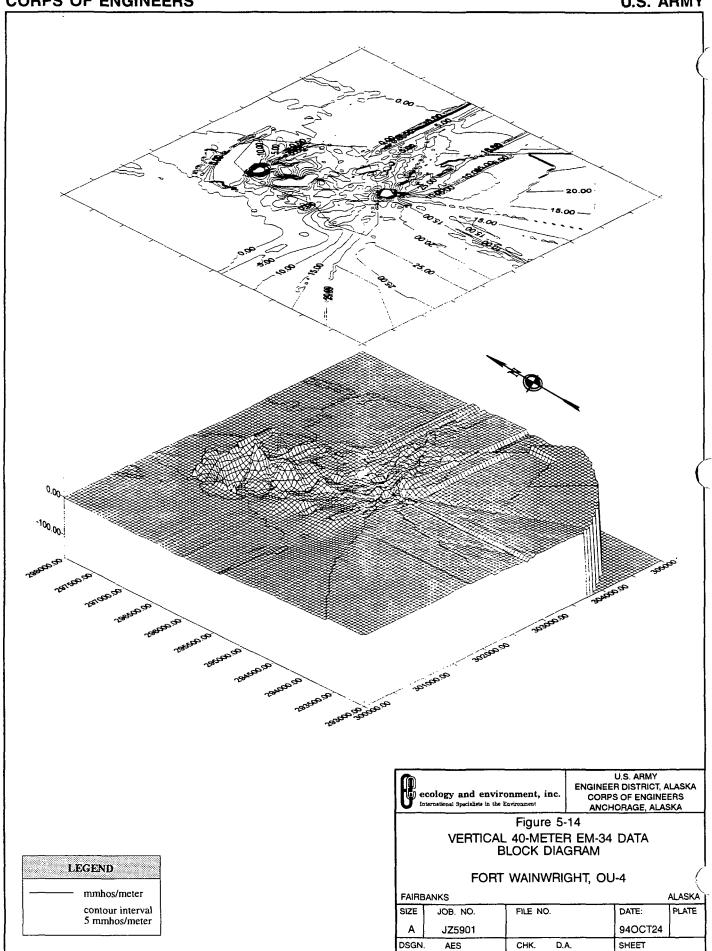
FAIRBANKS ALASKA PLATE SIZE JOB. NO. FILE NO. DATE: 940CT24 Α JZ5901 SHEET DSGN. AES СНК. D.A.

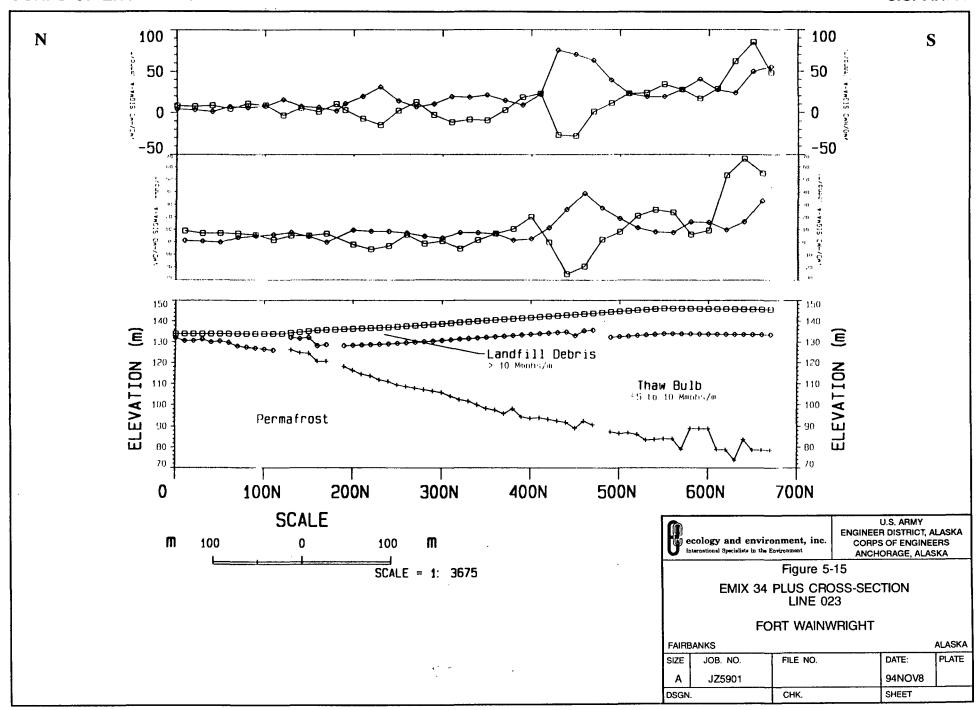
LEGEND

mmhos/meter

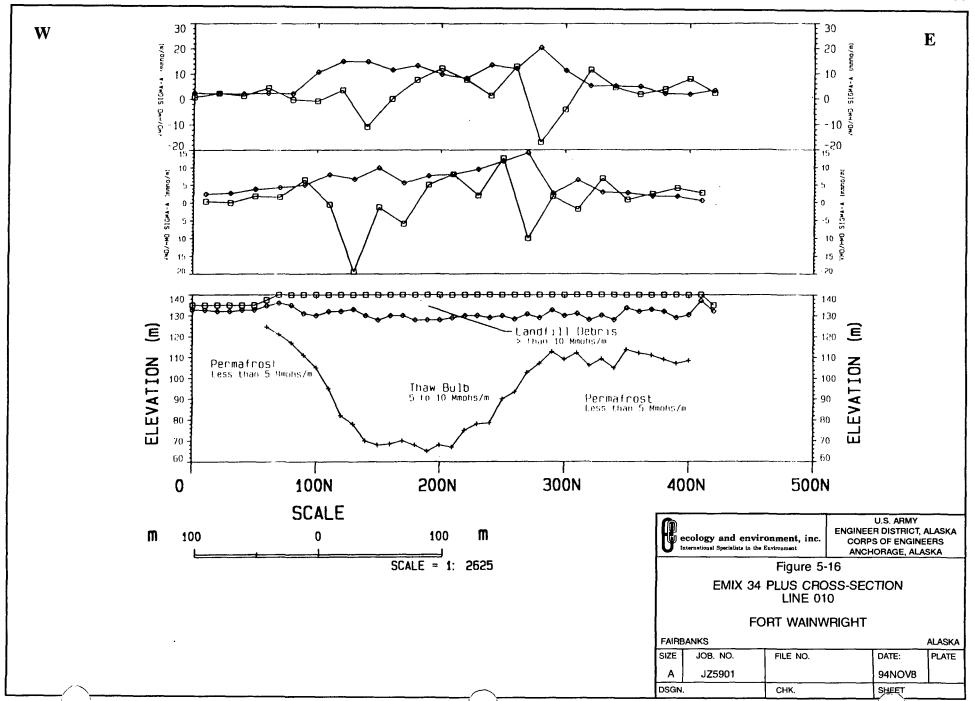
contour interval

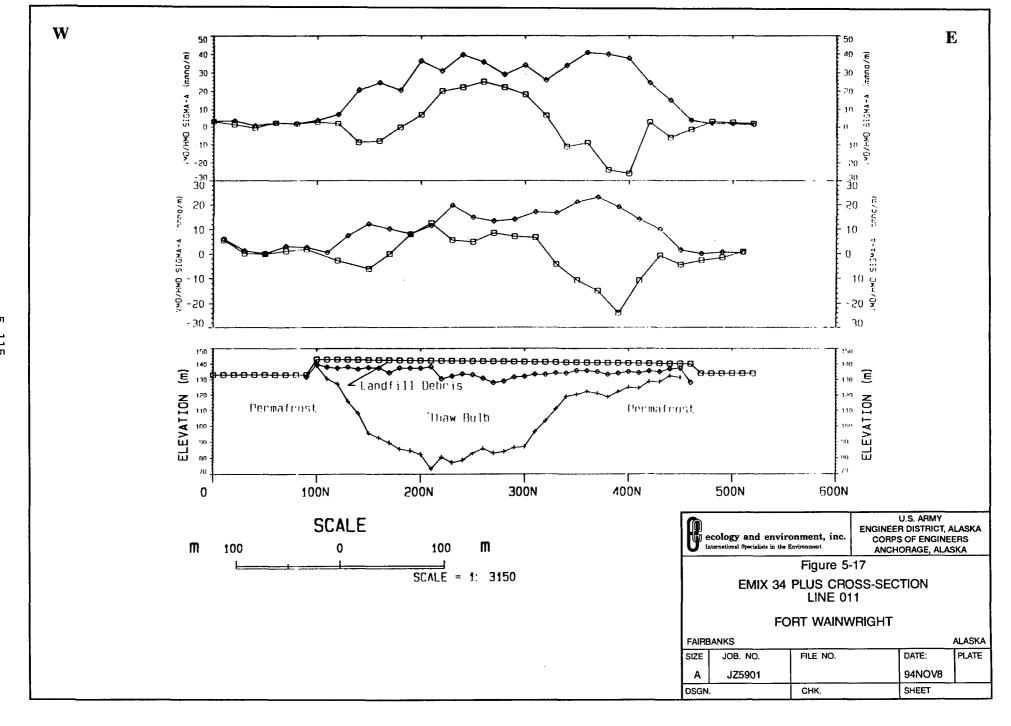
5 mmhos/meter

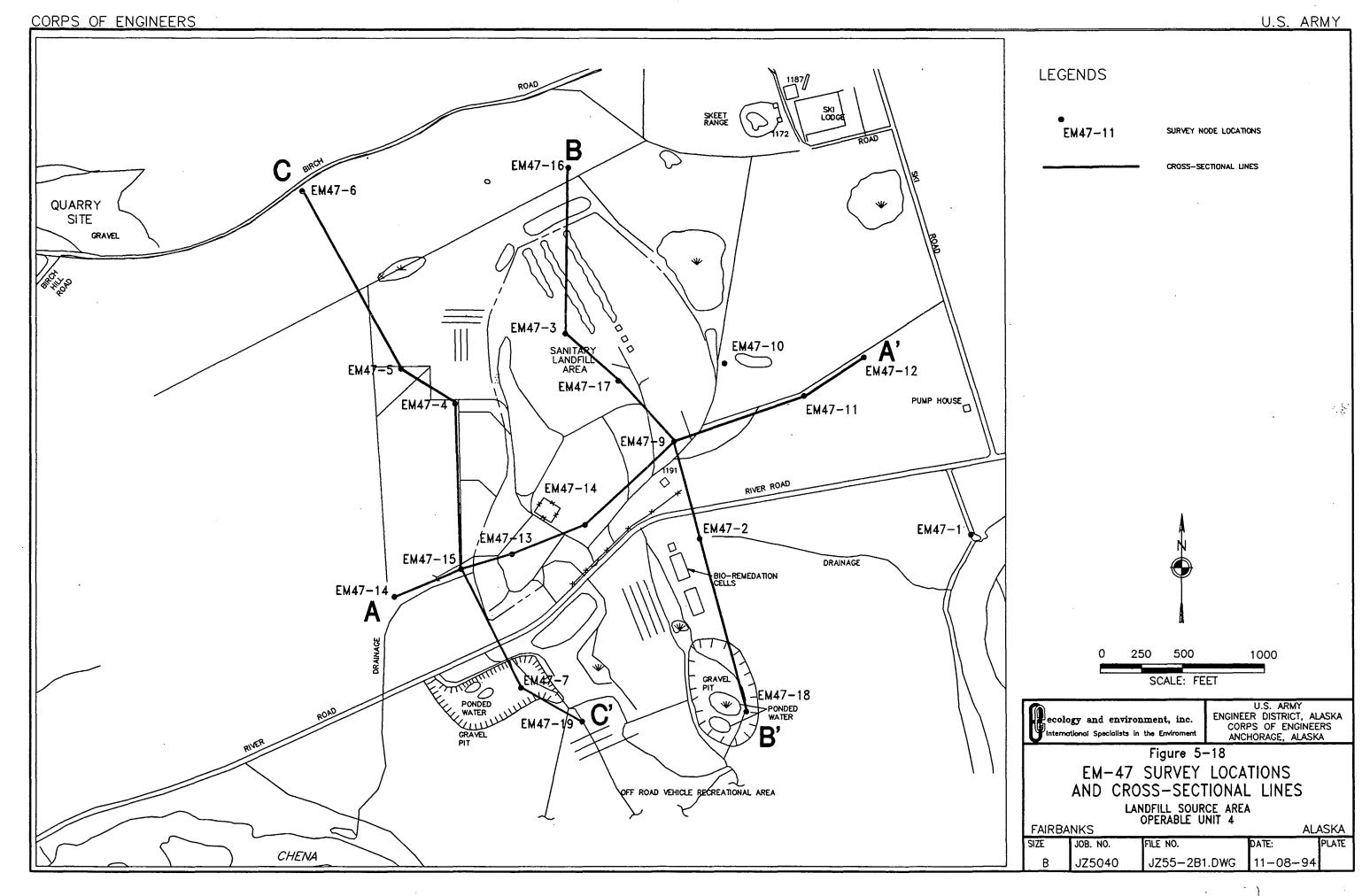


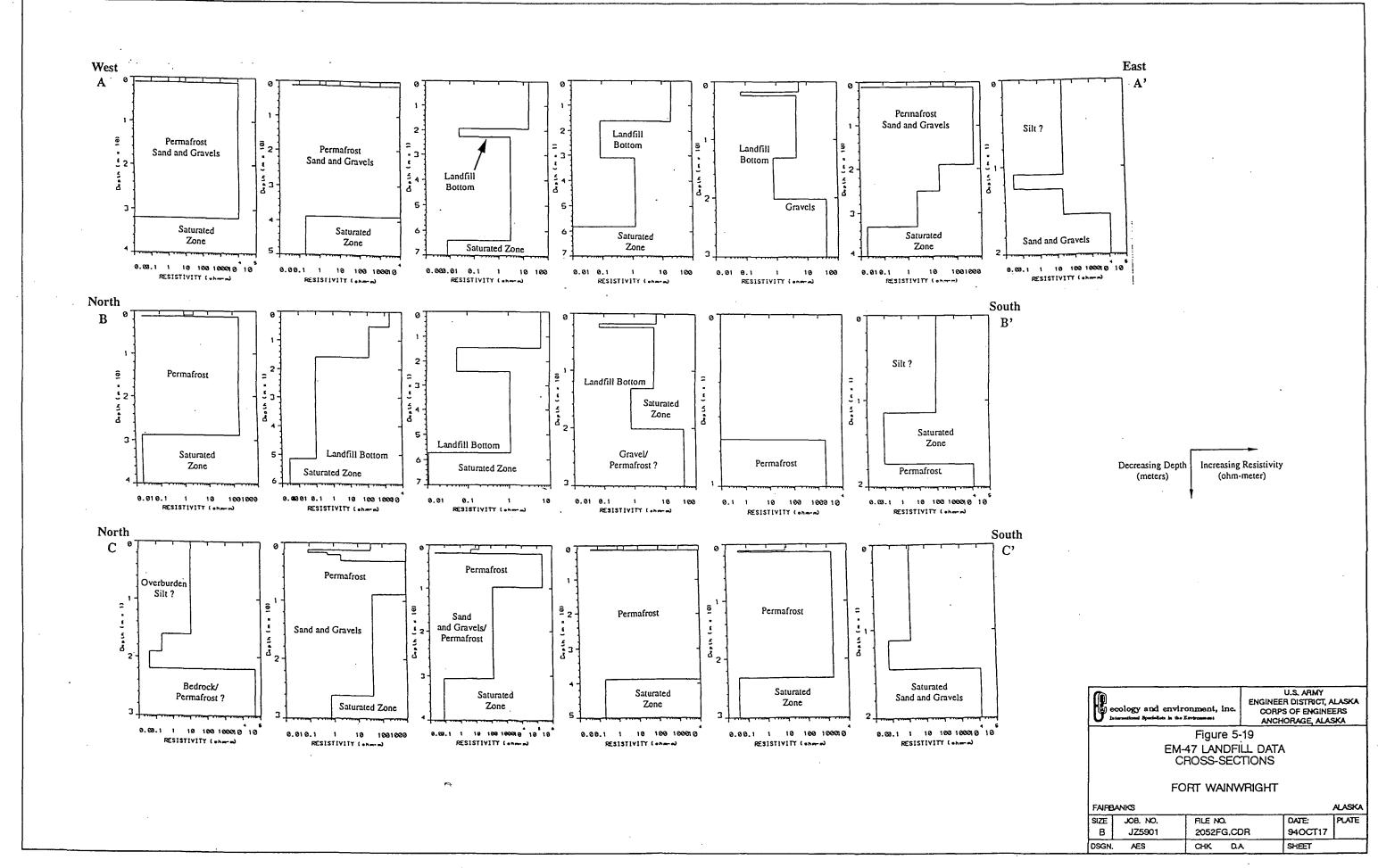


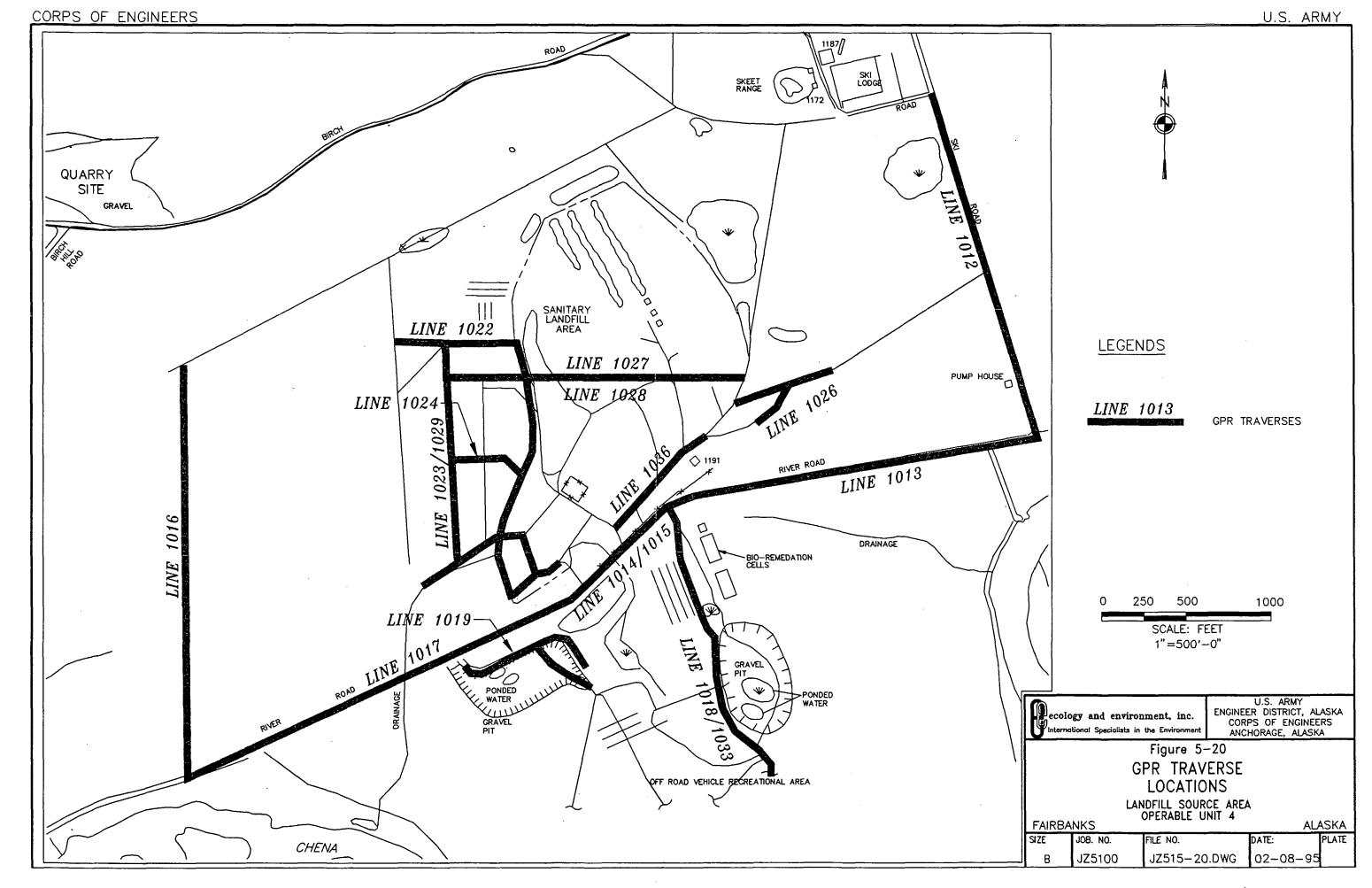
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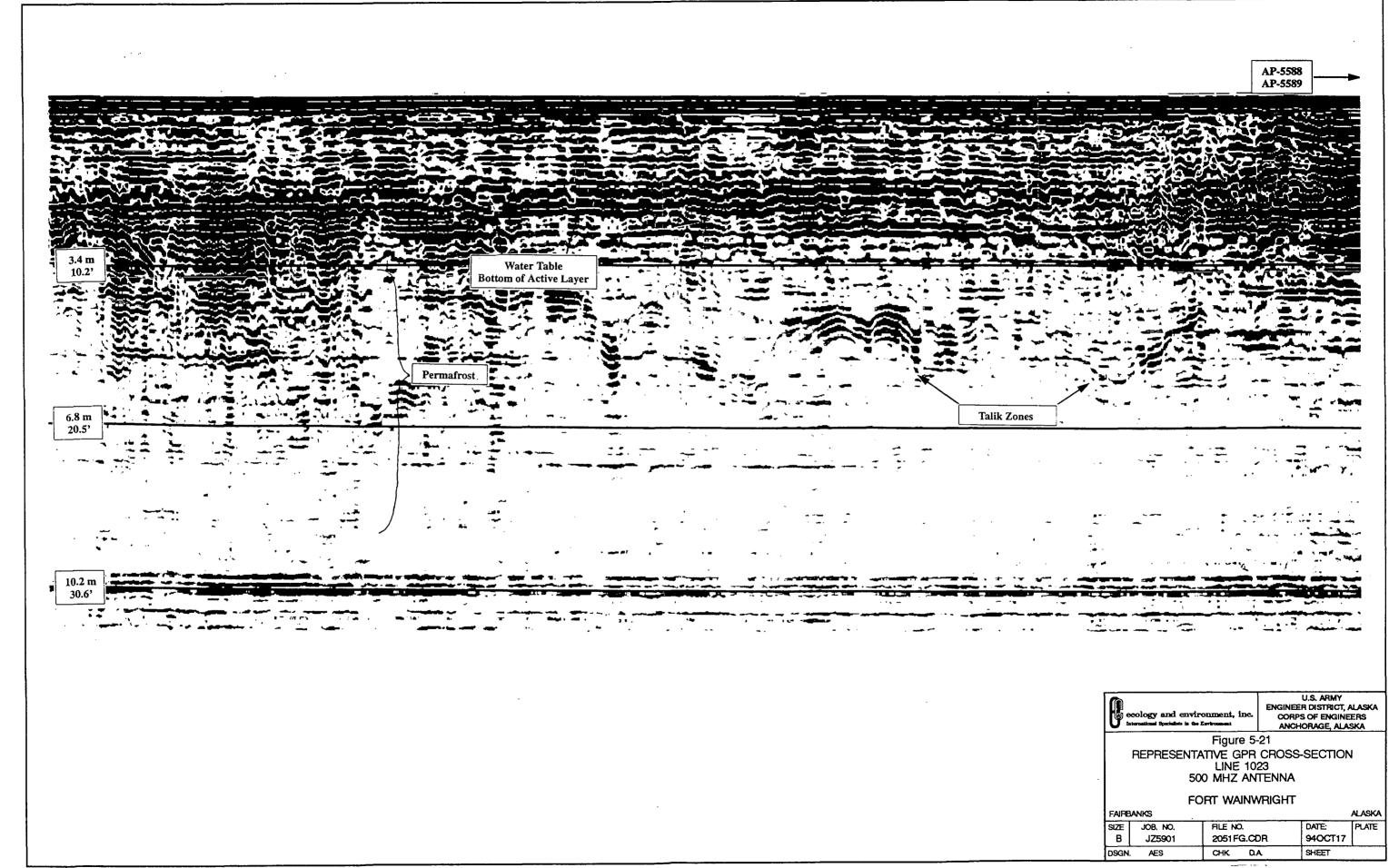


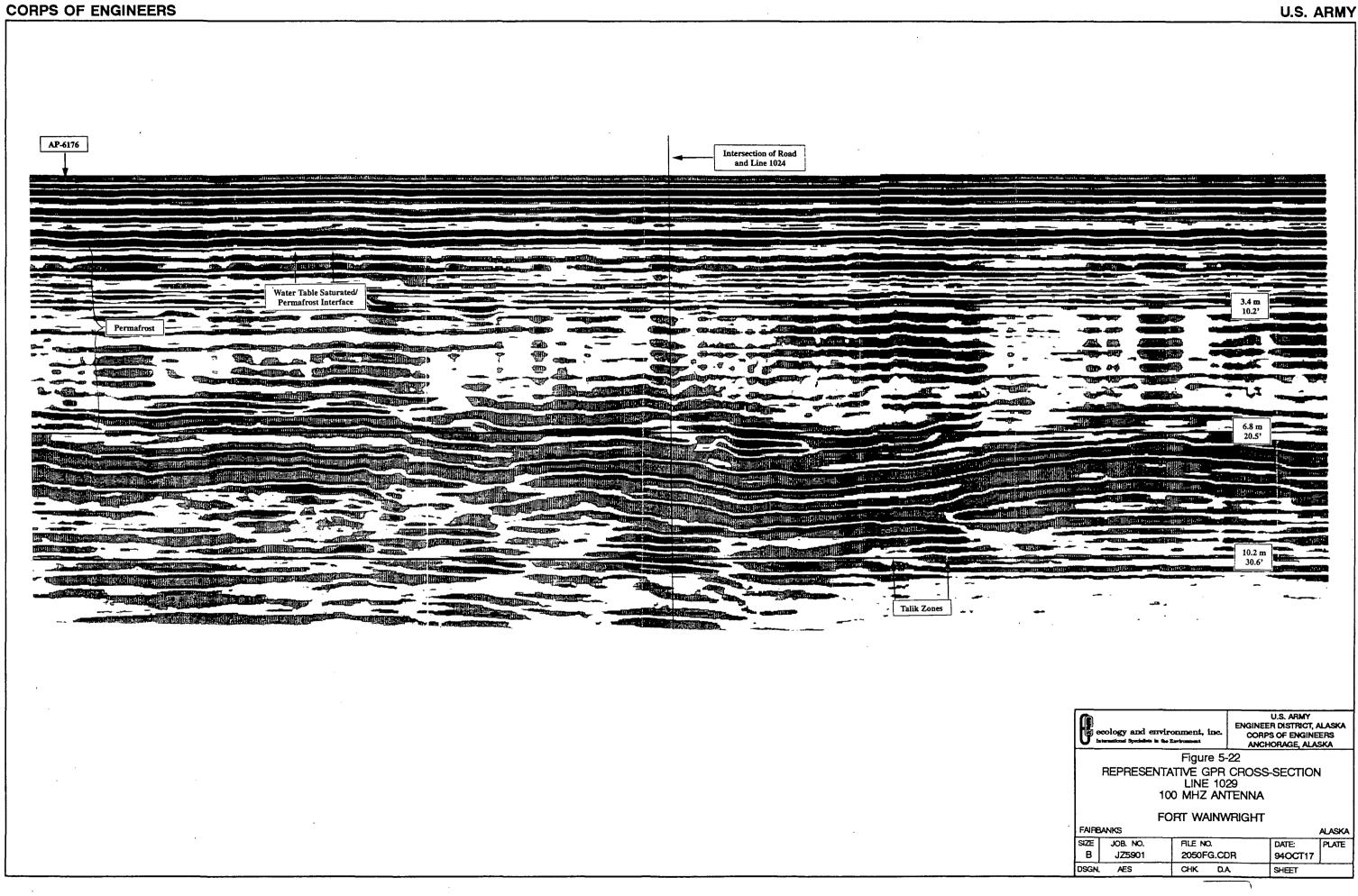


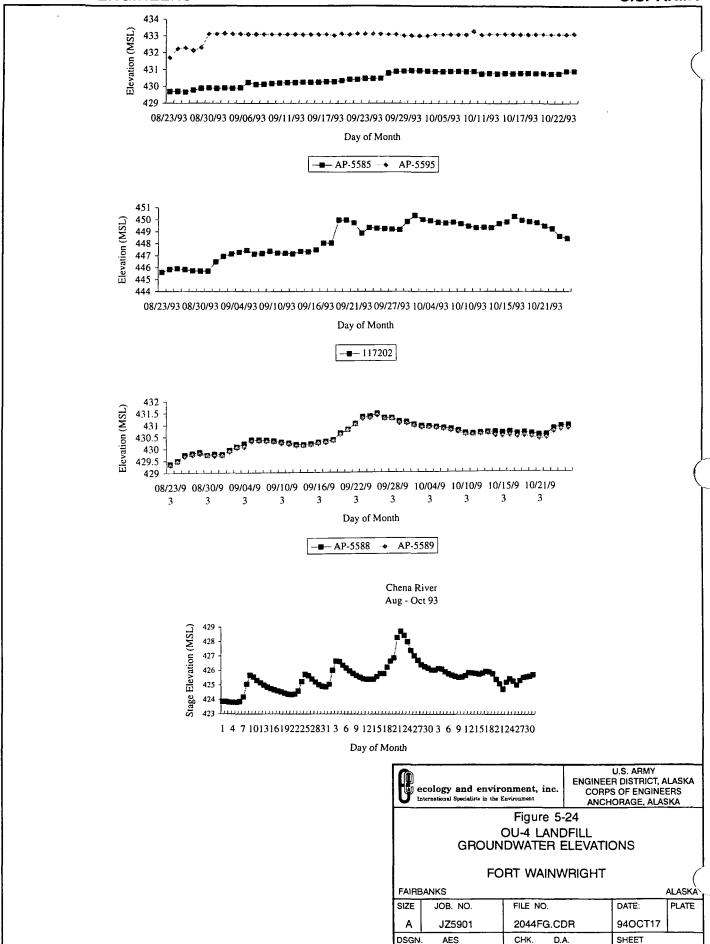


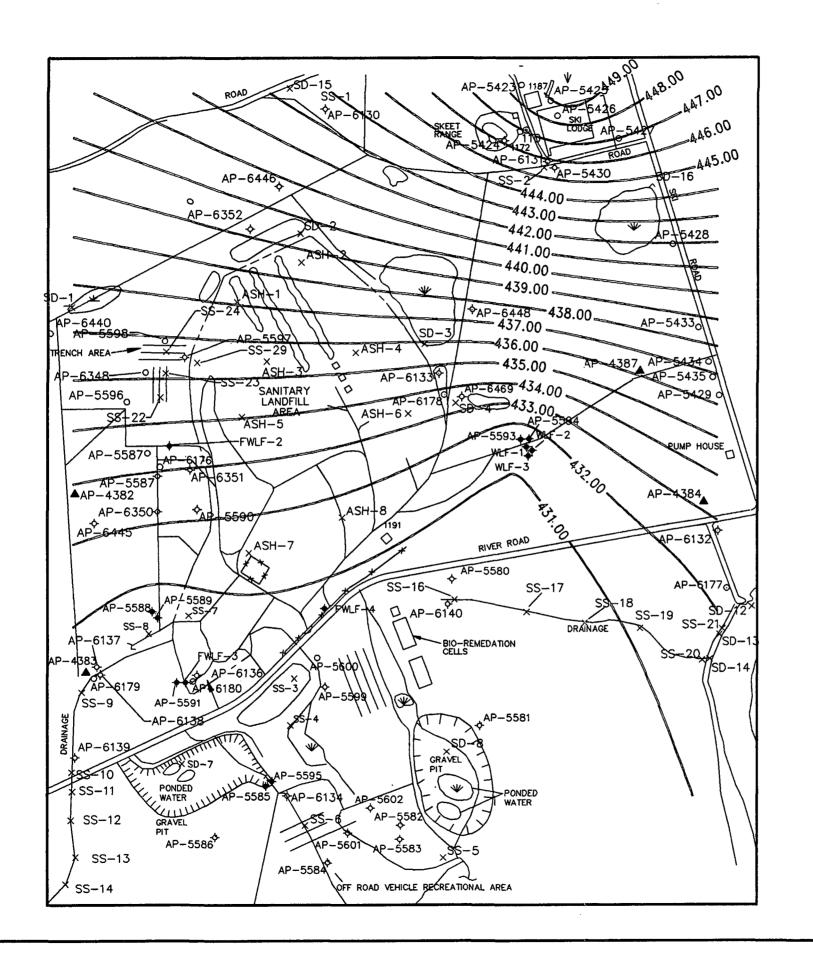






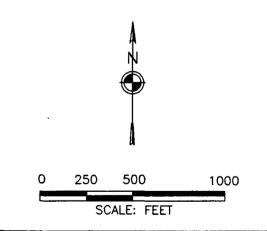






AP-5430 _•	MONITORING WELL/ SOIL BORING DESIGNATION (NEW WELLS)
♦	NEW WELLS
+	EXISTING WELLS
A	PEZOMETER
©	DOMESTIC WELL
-440.00	GROUNDWATER CONTOUR INTERVAL 1.0 FOOT

GROUNDWATER ELEVATION	
WELL	ELEVATION (FEET ABOVE MEAN SEA LEVEL)
AP5585	430.77
AP5588	430.61
AP5591	430.68
AP5593	431.22
FWLF3	430.64
FWLF4	430.8
AP6132	432.78
AP6137	430.58
AP6139	430.49
117202	449.73



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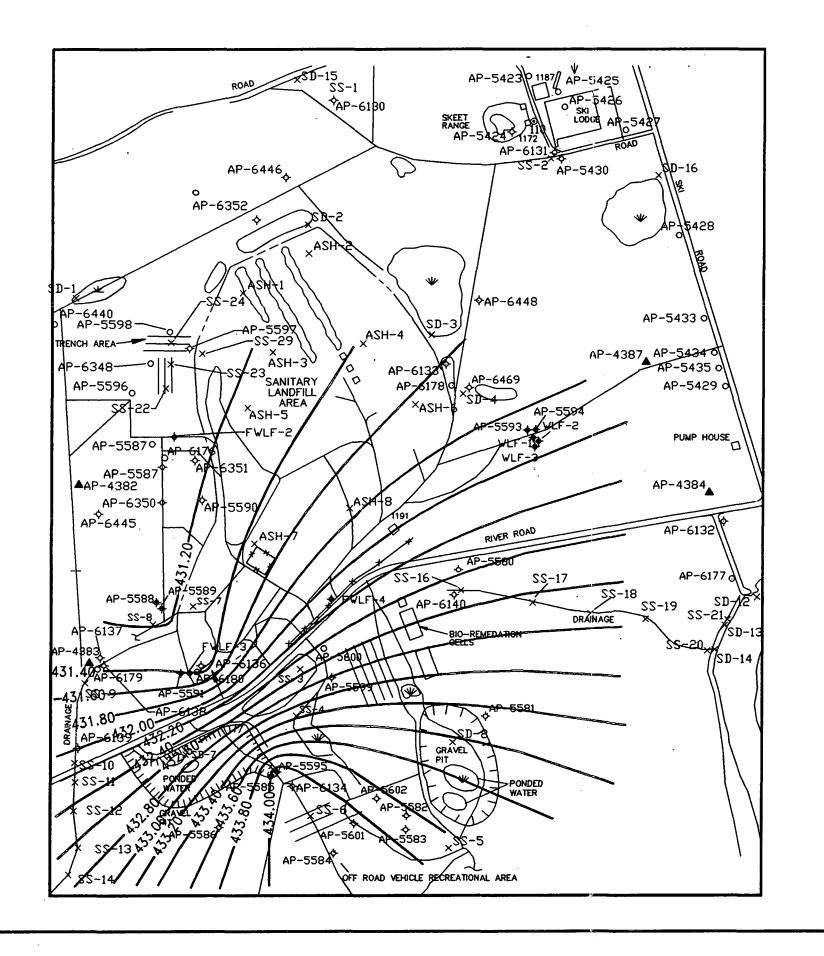
Figure 5-25a
OCTOBER 20, 1993 SHALLOW
GROUNDWATER ELEVATION CONTOURS
LANDFILL SOURCE AREA
OPERABLE UNIT 4

 FAIRBANKS
 ALASKA

 SIZE
 JOB. NO.
 FILE NO.
 DATE:
 PLATE

 B
 JZ5100
 JZ515-25.DWG
 03-02-95

U.S. ARMY

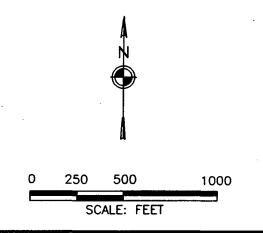


CORPS OF ENGINEERS

LEGEND

AP-5430	MONITORING WELL/ SOIL BORING DESIGNATION (NEW WELLS)
\$	NEW WELLS
+	EXISTING WELLS
•	PIEZOMETER
⊚	DOMESTIC WELL
-432.20	GROUNDWATER CONTOUR INTERVAL 0.20 FEET

MONITORING WELLS CONTOURED	
WELL	ELEVATION (FEET ABOVE MEAN SEA LEVEL)
AP5589 AP5594 AP5595 AP6133 AP6134 AP6138	430.45 431.19 433.10 431.23 430.66 431.40



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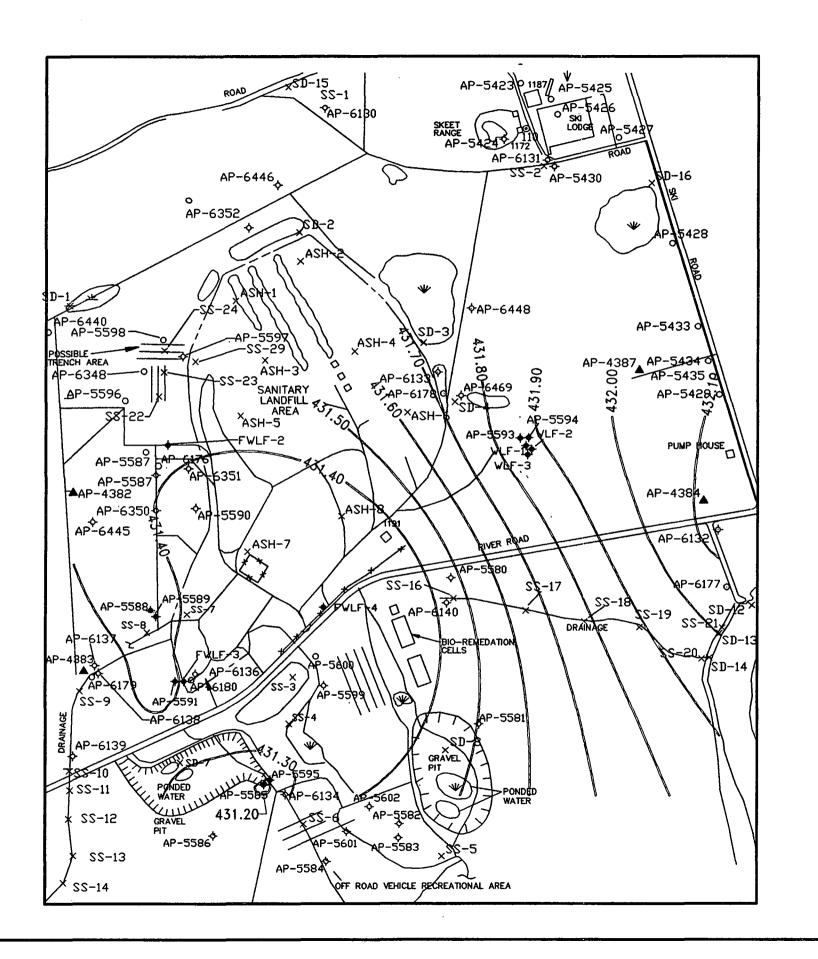
Figure 5-25c
OCTOBER 20, 1993 DEEP GROUNDWATER
ELEVATION CONTOURS

LANDFILL SOURCE AREA OPERABLE UNIT 4

 FAIRBANKS
 ALASKA

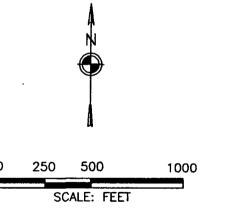
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 PLATE

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 JZ55-25X.DWG
 03-01-95



AP-5430 •	MONITORING WELL/ SOIL BORING DESIGNATION (NEW WELLS)
♦	NEW WELLS
+	EXISTING WELLS
A	PIEZOMETER
•	DOMESTIC WELL
422.00	GROUNDWATER CONTOUR INTERVAL 0.2 FEET

MON	MONITORING WELLS CONTOURED	
WELL	ELEVATION (FEET ABOVE MEAN SEA LEVEL)	
AP5585 AP5588 AP5591 AP5593 FWLF2 FWLF3 FWLF4 AP6132 AP6137 AP6139	431.48 431.43 431.53 431.88 431.42 431.25 431.04 432.14 431.34 431.27	



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Figure 5-26a

U.S. ARMY
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CORPS OF ENGINEERS
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ALASKA

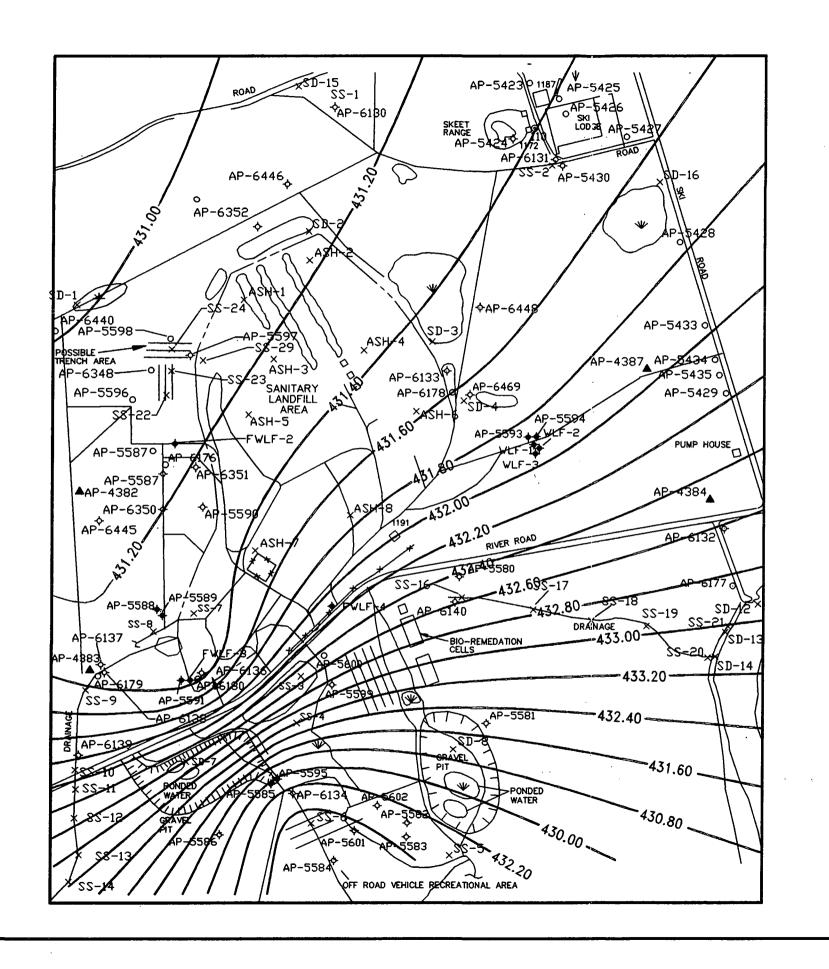
JULY 11 1994 SHALLOW GROUNDWATER ELEVATION CONTOURS
LANDFILL SOURCE AREA

LANDFILL SOURCE AREA
OPERABLE UNIT 4
FAIRBANKS

 ZE
 JOB. NO.
 FILE NO.
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U.S. ARMY

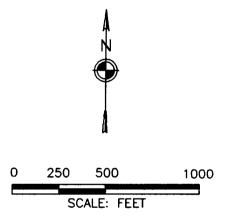


CORPS OF ENGINEERS

LEGEND

AP-5430 _•	MONITORING WELL/ SOIL BORING DESIGNATION (NEW WELLS)
*	NEW WELLS
+	EXISTING WELLS
A	PIEZOMETER
•	DOMESTIC WELL
	GROUNDWATER CONTOUR INTERVAL 0.2 FEET

MONITORING WELLS CONTOURED	
WELL	ELEVATION (FEET ABOVE MEAN SEA LEVEL)
AP5589 AP5594 AP5595 AP6134 AP6136 AP6138	431.23 431.86 434.07 431.41 431.29 431.33



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Figure 5-26a

U.S. ARMY
ENGINEER DISTRICT, ALASKA
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

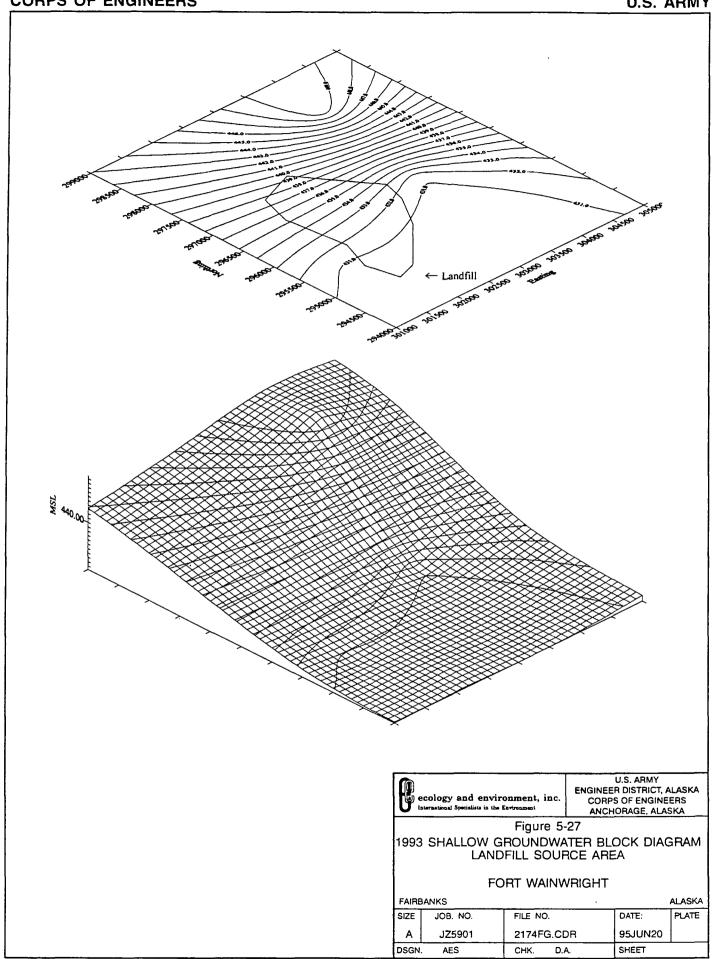
JULY 1994 DEEP GROUNDWATER ELEVATION CONTOURS

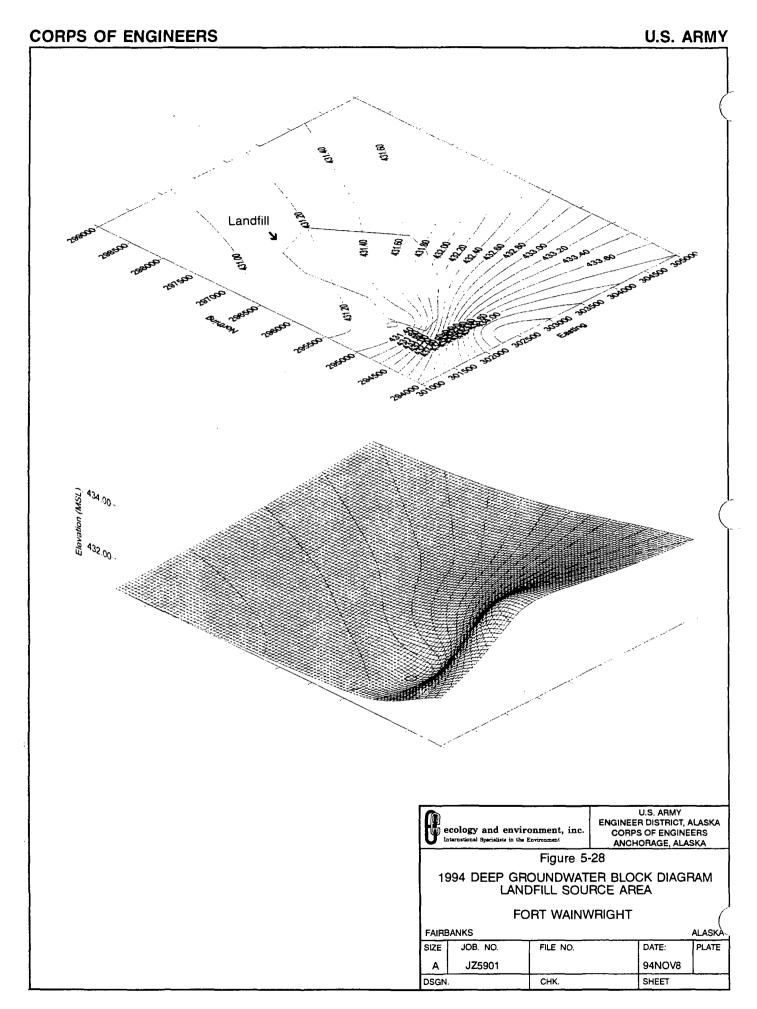
LANDFILL SOURCE AREA
OPERABLE UNIT 4

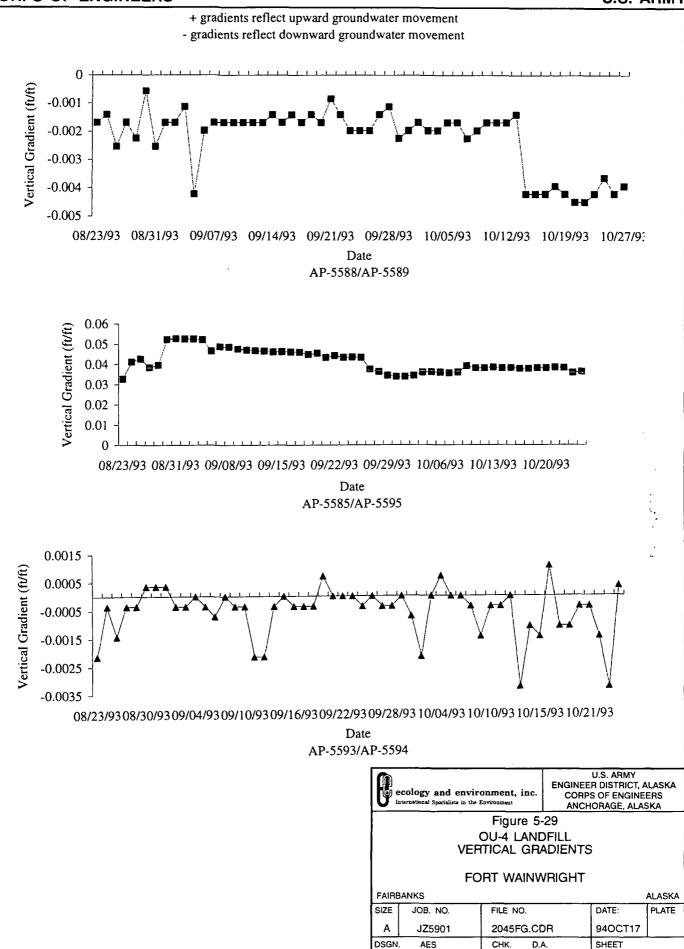
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 ALASKA

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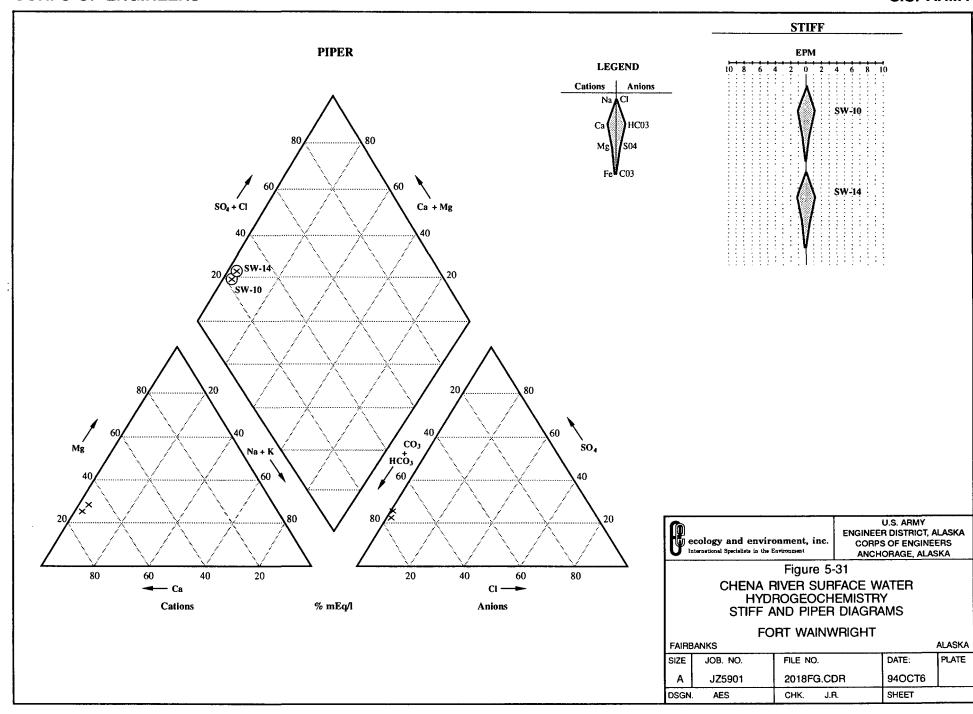
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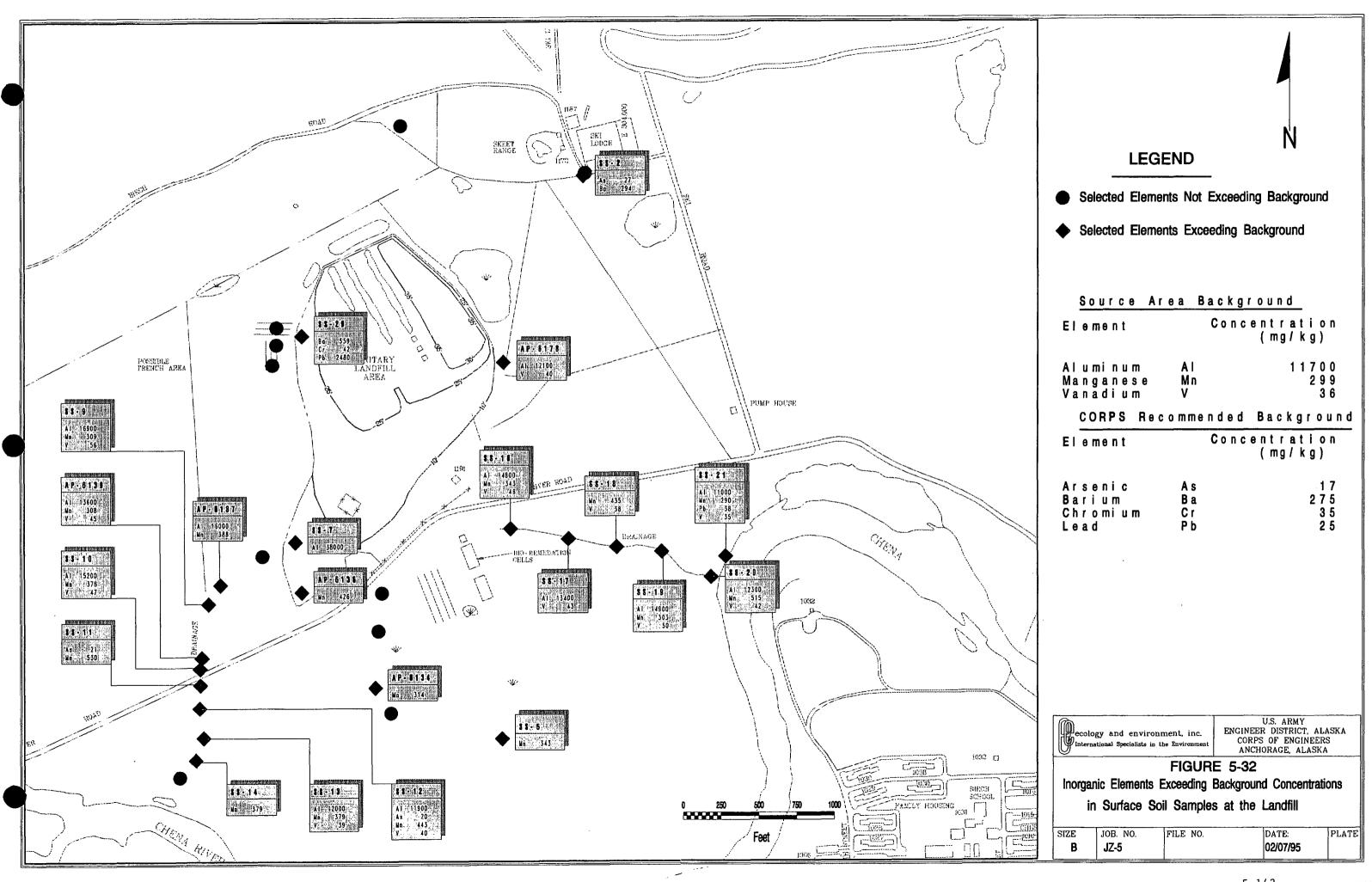


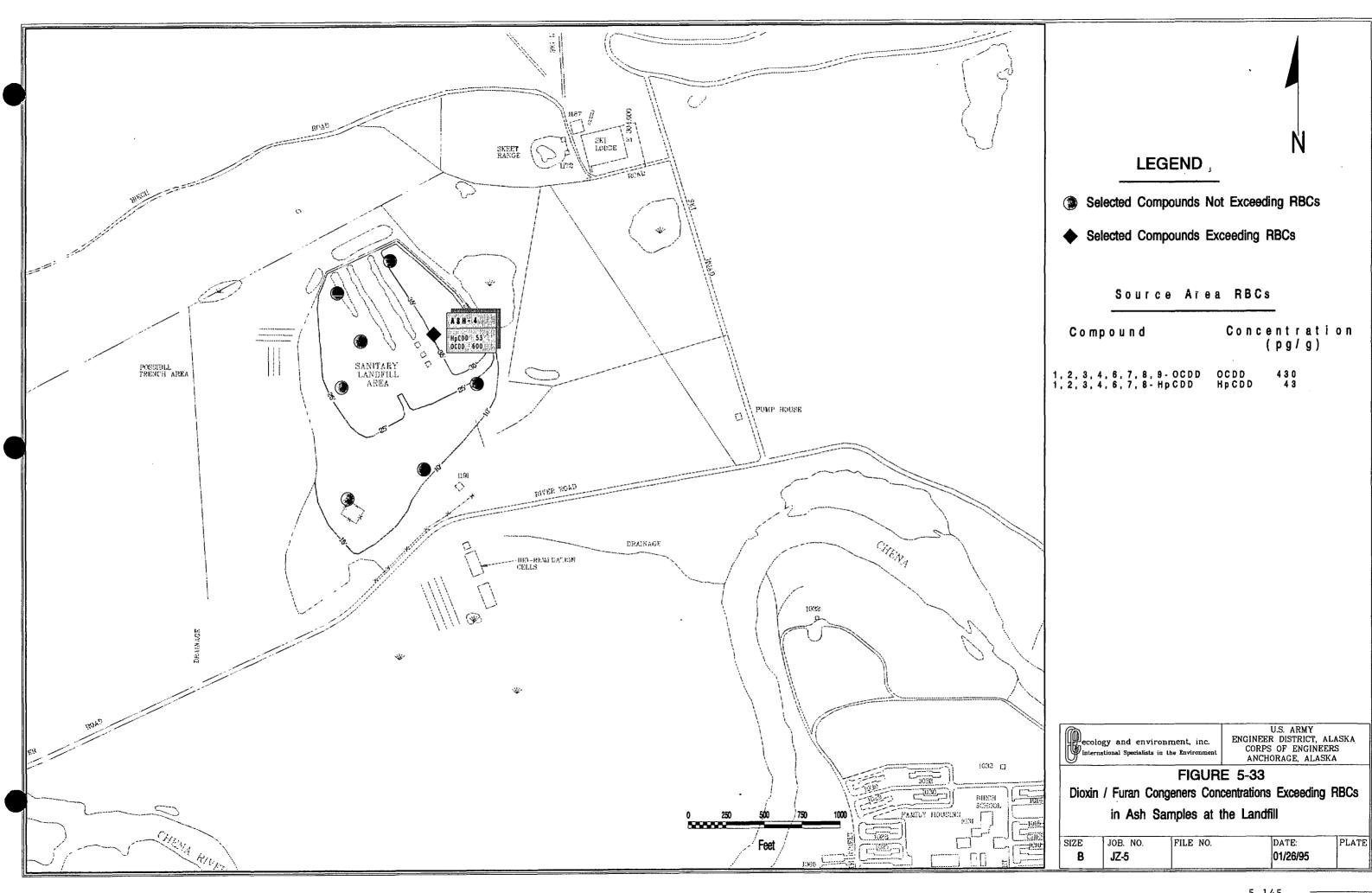


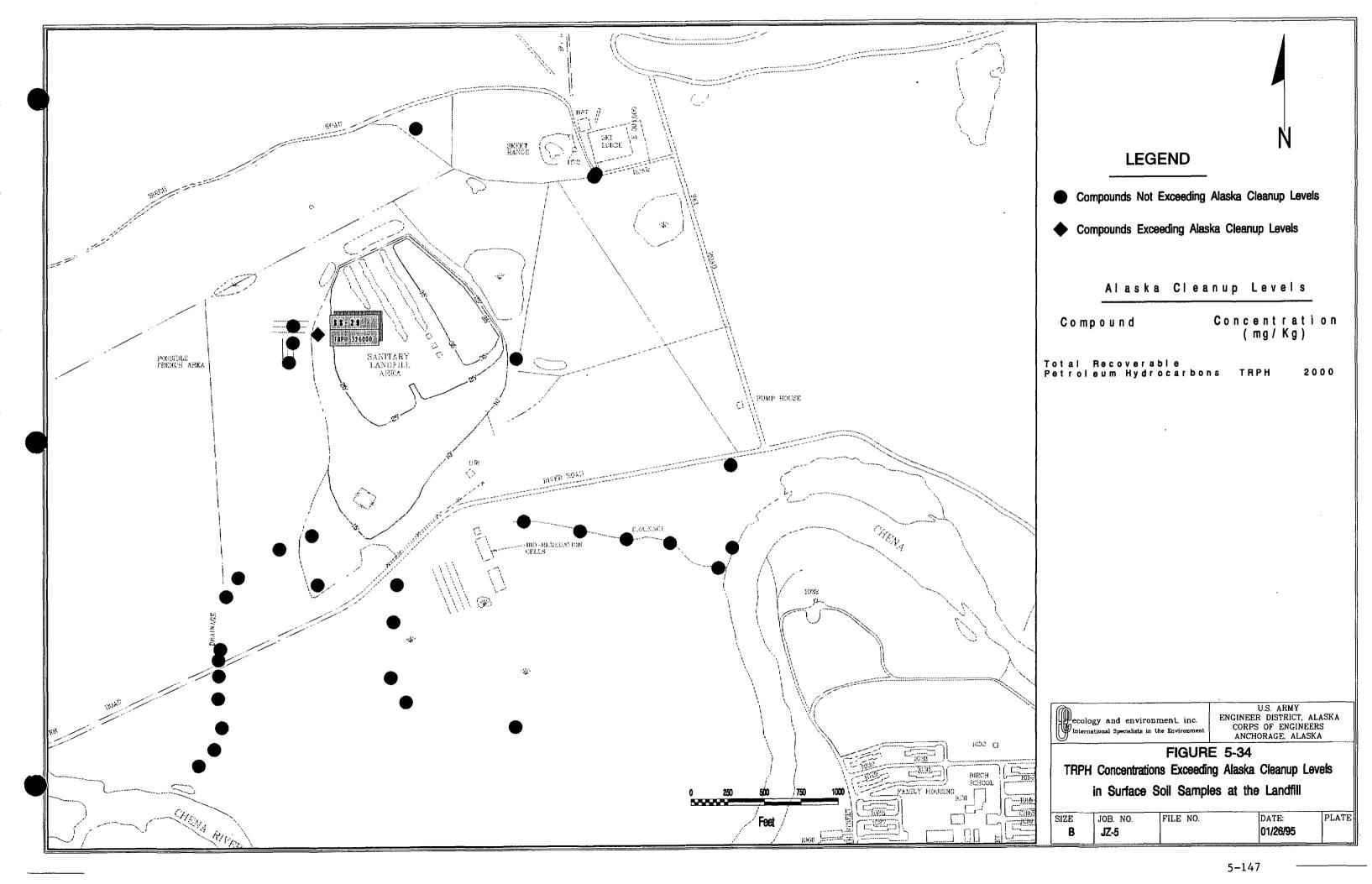


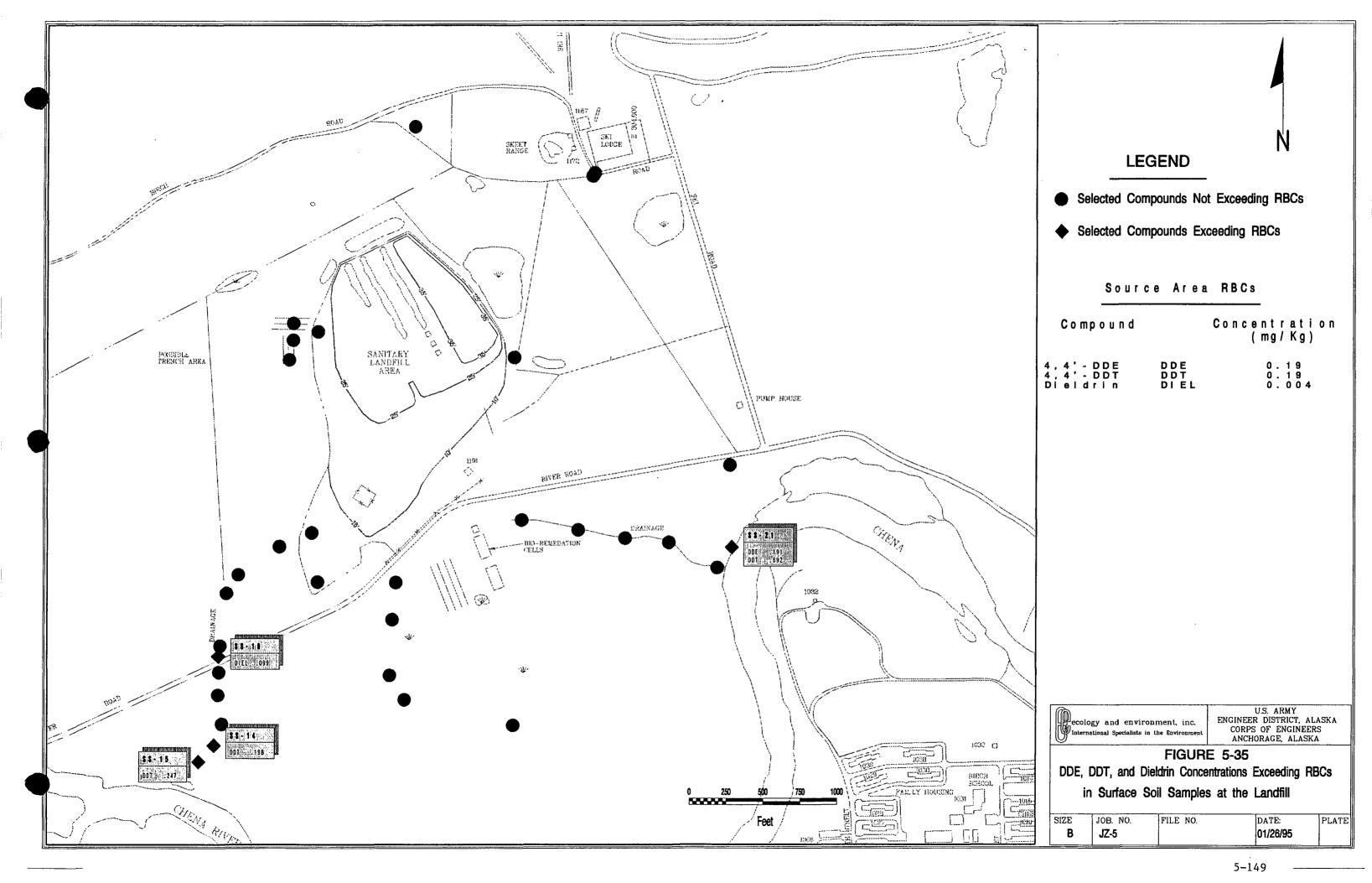
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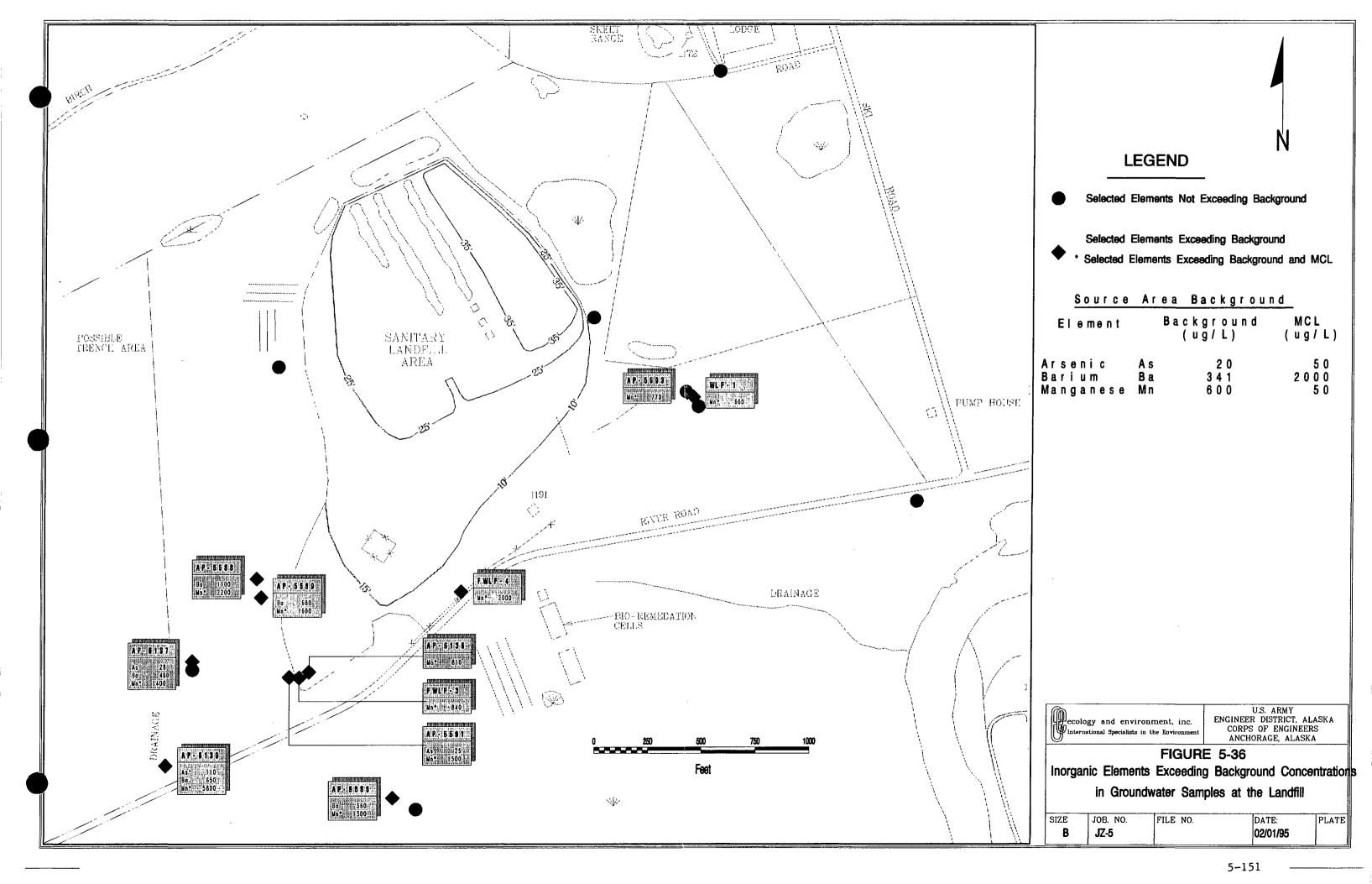


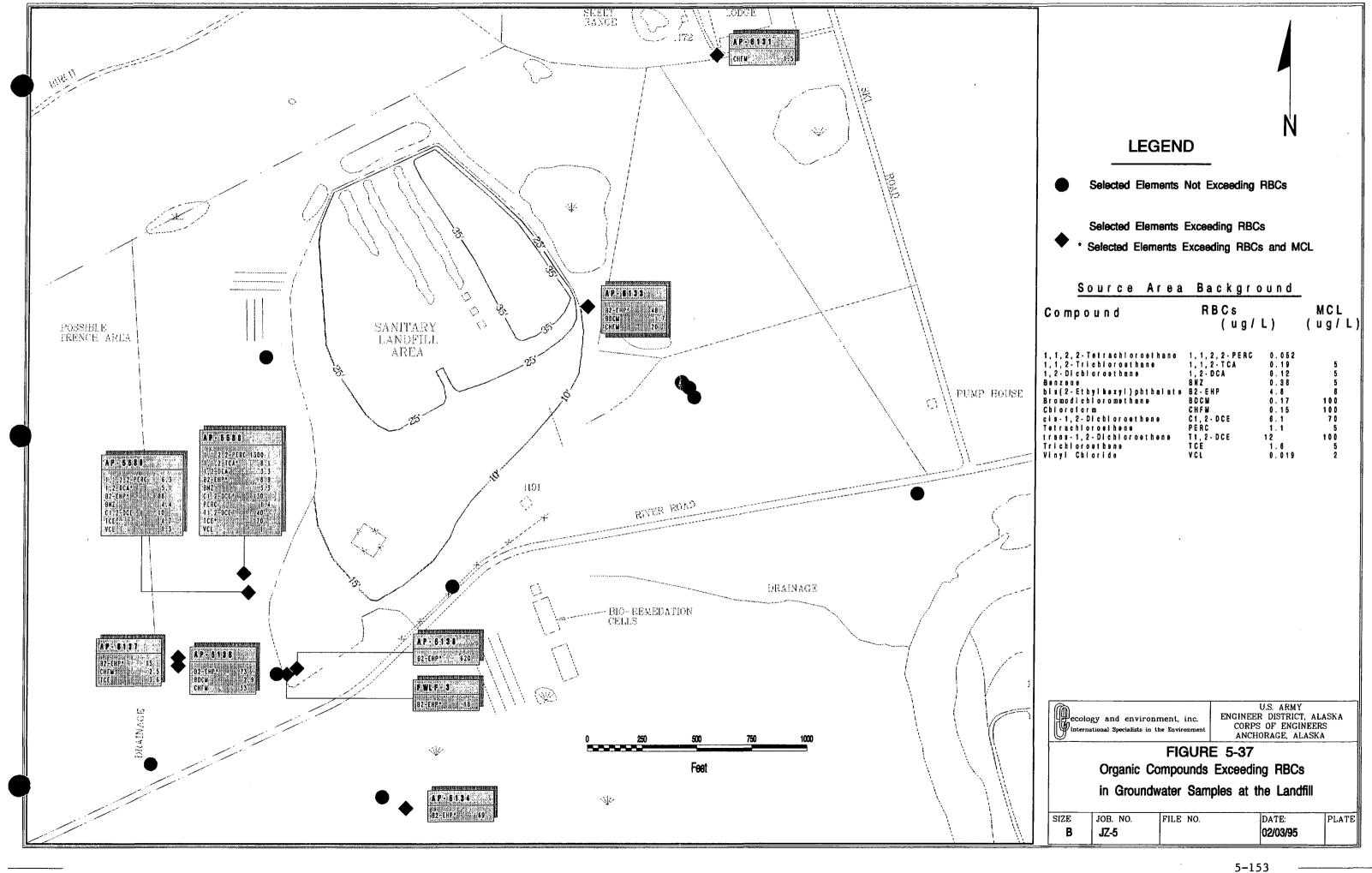


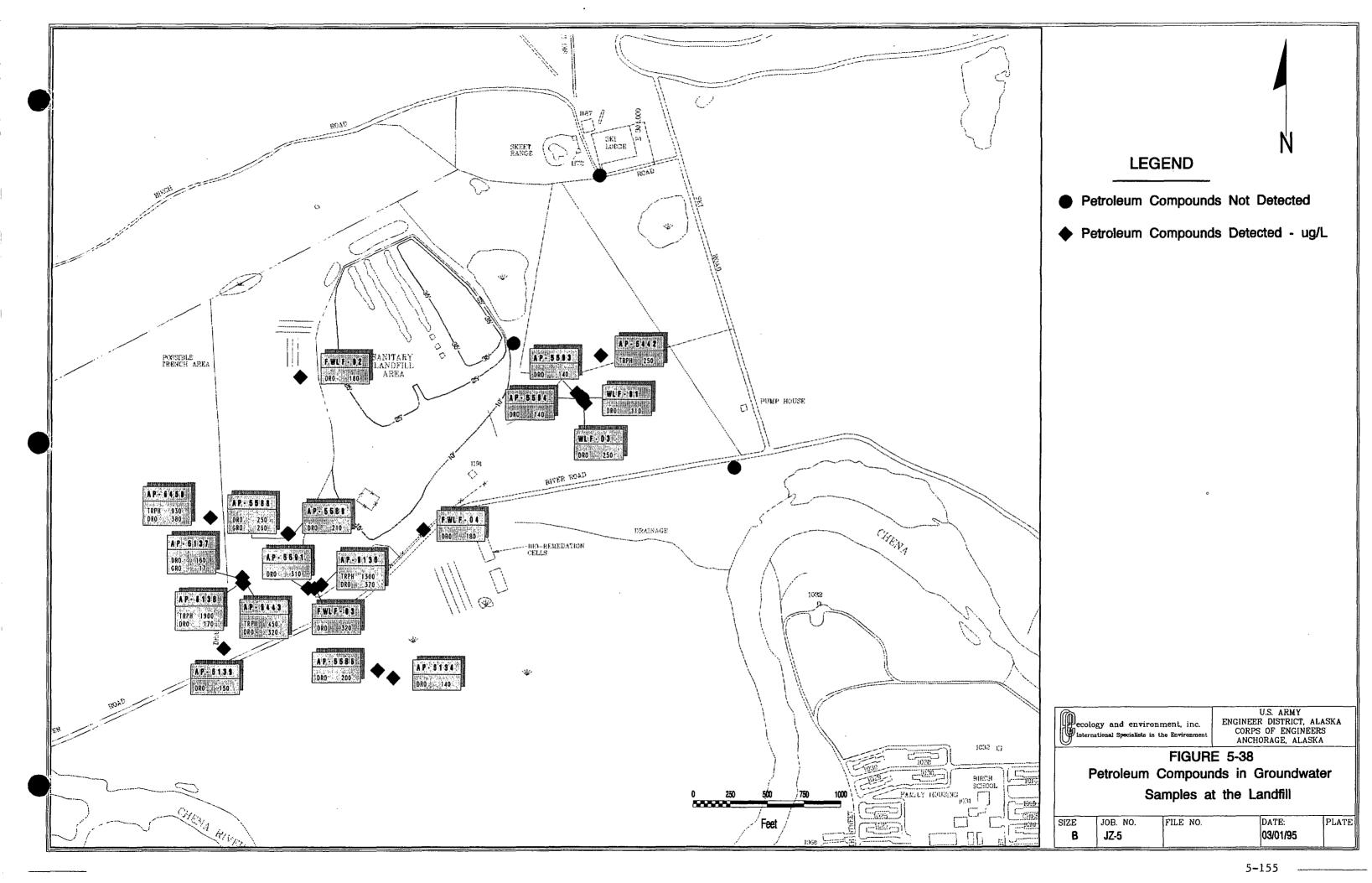












6. COAL STORAGE YARD SOURCE AREA

The following section presents the data collected from RI activities for the CSY. For descriptive purposes, the CSY consists of an active coal pile that is east of the cooling pond and directly south of the power plant (see Figure 1-3). This coal pile is currently used to stockpile loads of coal received by rail. Directly south of the active coal pile is a second coal pile referred to as the *emergency coal pile*. Directly east of the active coal pile is the UST area, which is surrounded by a wire fence.

Data and discussions regarding characterization of the CSY Source Area, including data obtained from previous investigations, are presented in four sections. The first section discusses the physical characteristics of the CSY Source Area, as defined by lithologic descriptions of surface and subsurface soils, and characterizes groundwater occurrence and hydraulic parameters. The second section discusses the nature of contamination determined from analytical work, and is followed by a section that describes the extent of contamination. The final section discusses the chemical-specific ARARs appropriate for the CSY Source Area. For 1993 and 1994 RI activities, a combination of existing wells and new monitoring wells and soil borings were utilized for characterization, as indicated in Table 6-1.

6.1 PHYSICAL CHARACTERISTICS OF THE COAL STORAGE YARD SOURCE AREA

Physical characteristics of the CSY and the location where samples of soil, sediment, and groundwater were collected and the location where samples of soil, sediment, and groundwater were collected are discussed in this section. The physical descriptions provided are based on matrix-specific physical parameter analysis (i.e., sieve analysis) on soil samples

and visual observations made in the field. Figure 6-1 depicts all of the CSY surface and subsurface sampling locations, including monitoring well locations.

6.1.1 Surface Soils and Sediments

Surface soil samples and sediment samples were collected from areas where surface water runoff from the CSY likely would occur, typically within the drainage swales along the roads near the CSY and along the cooling pond. Water was not present in any of the drainage areas during the 1993 field activities. Five surface soil samples and 10 sediment samples were collected from the CSY Source Area. Analytical results for the surface soil and sediment samples collected during the 1993 field activities at the CSY are discussed in Sections 6.2.1 and 6.2.3. No surface soil or sediment samples were collected during 1994 field activities.

In addition to the chemical characterization of soil samples, physical parameters were tested on four samples for feasibility study purposes. The physical parameters included: Atterberg limits, specific gravity, moisture content, and grain size using ASTM test methods D-4318, 0854, 02216, D-421, and D-422, respectively.

Surface soil samples were collected at soil boring locations AP-6141, AP-6158, AP-6159, AP-6161, and AP-6162. Samples 93CSY016SS from AP-6158, 93CSY019SS from AP-6162, and 93CSY028SS from AP-6161 were collected adjacent to the coal pile. The samples were collected from the original ground surface beneath the base of the coal, which in some locations was up to 3-feet-thick. Five surface soil samples were assigned an ASTM D-2487 classification of silty sand or SM, and one surface soil was classified as ML (see Table 6-2). Figure 6-1 shows the general surface soil characteristics observed at the CSY.

Sediment samples SD-1 and SD-2 were collected northwest of the cooling pond, and SD-3 and SD-4 were collected southwest of the cooling pond to provide information on drainage to the cooling pond and associated power plant activities. Sediment samples SD-5 through SD-9 were collected within the cooling pond and along the sides to provide information on cooling pond sediment contamination. As discussed previously, sediment sampling in the cooling pond was complicated by the amount of aquatic vegetation on the bottom of the pond. As a result, sediment samples were collected along the edges of the pond. An additional sediment sample (SD-10) was collected to provide local background conditions.

6.1.2 Subsurface Soil

Fifteen soil borings were completed at the CSY during the 1993 field activities; four of these borings (AP-6141, AP-6142, AP-6143, and AP-6144) were completed as monitoring wells (see Section 6.1.3). During 1994 field activities, seven additional borings were drilled to install groundwater monitoring wells AP-6518 through AP-6524. Analytical results for subsurface soil samples collected during the 1993 field activities at the CSY are discussed in Section 6.2.2. No soil samples were collected for analysis during the 1994 field activities.

All soil borings were advanced until groundwater was encountered at an average depth of 15 feet BGS. Soil boring location AP-6159 was selected to provide information on conditions adjacent to but upgradient of the coal piles. Soil boring locations AP-6158 and AP-6161 were chosen to characterize the emergency coal pile area and to provide upgradient conditions of the active coal pile. Soil boring locations AP-6160, AP-6162, AP-6163, AP-6164, AP-6165, AP-6166, AP-6167, and AP-6168 were chosen to characterize the areas immediately surrounding and beneath the active coal pile, and the fenced storage yard.

The subsurface soils at the CSY consisted of silty sand and sandy silts, and poorly-graded sand and gravel. In the area near the power plant and the coal piles, approximately 2 to 4 ft of coal and/or fly ash were encountered on top of native soil. Two soil borings (AP-6160 and AP-6165) were drilled through the top of the coal pile to characterize potential subsurface contamination that was detected in Geoprobe™ groundwater sample results. Facility personnel at the CSY used a bulldozer to create a pathway and an area near the top of the coal pile for the track-mounted drilling rig transport and set up. The soil borings extended through a coal thickness of approximately 21.8 and 24.13 feet, respectively, before encountering native soils.

To provide information for a potential treatability study and for selecting remedial alternatives, physical parameter testing was made on subsurface soil collected from three soil borings and four surface soil samples, collected from four soil boring locations. Tests conducted by NPDML include soil classification, percent moisture, specific gravity, grain size, moisture content, and Atterberg limits by ASTM D-2487 and TM5-818-2 laboratory methods (see Appendix E). Table 6-1 summarizes the laboratory and field soil classification data for soil.

A schematic of the general stratigraphy at the CSY is shown in Figure 6-2. The figure consists of a northwest to southeast geologic cross section and is based on the lithology

logged from the soil borings completed at the CSY during the 1993 field activities. Subsurface soils characterized in cross section A-A' at the CSY consisted predominantly of poorly graded sand from the ground surface to a depth of approximately 60 feet BGS in the northwest segment of the cross section, based on borehole data from AP-6142. On the southwest segment of the cross section, coal ranges in thickness from a 3-foot surficial cover to a 25-foot-thick coal pile. The thickest section of the active coal pile was estimated at 45 feet at location AP-6165. The active coal pile overlies predominantly gravelly sand and poorly graded sand with gravel. The underlying soils consist of interlayered sandy gravel with poorly graded sand. On the southwest segment of the cross section, lenses of silty sand, sandy silt, and silt are found to 30 feet BGS. No permafrost was encountered in any of the borings completed at the CSY, nor was coal fly ash identified at depth beneath the surface of native soils in any of the soil borings. Based on as-built diagrams (Corps 1949) of the power plant, subgrade concrete footings and the slab for the foundation are above the groundwater level that exists at approximately 12 feet BGS. Sheet pilings were driven down to an estimated 30 feet BGS during construction; however, most of these were removed except for small sections near the northwest corner of the facility. This small section is U-shaped at approximately 20 feet on each side and is not expected to be significant enough to influence groundwater flow.

6.1.2.1 Ground-Penetrating Radar

A GSSI SIR System 10A GPR unit was used to investigate the CSY and to supplement subsurface information. A GPR transect line was attempted from the edge of the cooling pond across the active coal pile. The GPR transect was conducted using the 100 MHz (Model 3207) antenna and the 500 MHz (Model 3102) antenna. Results of the GPR survey at the CSY revealed no identifiable subsurface features, within the sounding depth, which could be used to characterize the depth of the coal pile, contaminant plumes, permafrost, or other subsurface conditions. The coal appears to have attenuated the radar signals from the antenna unit.

6.1.3 Groundwater

The installation of shallow and deep monitoring wells for the RI included wells designed to sample groundwater from shallow and deeper sections of the aquifer underlying

the CSY (see Table 6-1). The CSY groundwater investigation program also utilized 11 previously installed monitoring wells and/or piezometers (AP-5508, AP-5509, AP-5510, AP-5511, AP-5517, AP-5734, AP-5735, AP-5736, and 3595-01/3595-02/3595-03) to provide groundwater elevations and borehole lithologic data. In 1993, four monitoring wells were installed to additionally characterize the aquifer in the CSY, as stated in Section 6.1.2. Two monitoring wells, AP-6141 and AP-6144, were completed at a depth of 30 feet BGS with 15 feet of screen straddling the water table. Well AP-6141 was installed to provide hydraulically upgradient and background conditions, while well AP-6144 was completed to identify downgradient conditions near the coal pile. Two monitoring wells were completed as a piezometer nest with one well installed at a depth of 60 feet BGS (AP-6143) and the other at a depth of 30 feet BGS (AP-6142), with screened intervals of 5 feet.

During the 1994 field season, seven additional monitoring wells were completed hydraulically downgradient of the coal pile and cooling pond (northwest), including three 2-inch ID (AP-6520, AP-6522, and AP-6524) and four 4-inch ID monitoring wells (AP-6519, AP-6518, AP-6521, and AP-6523). The wells completed during the 1994 field activities were installed to provide monitoring points for the shallow and deep aquifer between the contaminated groundwater source area and the active water supply wells; they were not lithologically logged. Monitoring wells AP-6520, AP-6522, and AP-6524 were completed at depths of approximately 30 feet BGS in the shallow aquifer zone. Monitoring wells MW-6519 and AP-6522 were completed at a depth of approximately 75 to 85 feet BGS in an intermediate zone of the aquifer. Monitoring wells AP-6518 and AP-6521 were completed at a depth of 181.5 feet BGS in a deeper aquifer zone.

Analytical results of groundwater samples collected during the 1993 and 1994 field activities at the CSY are discussed in Section 6.2.5. Well construction diagrams of the monitoring wells installed in 1993 are presented in Appendix B. Well construction diagrams for the 1994 monitoring wells will be included in the final RIR.

Following installation, all borings, monitoring wells, and selected sediment and surface soil samples locations were surveyed by the Corps for elevation and for northing and easting coordinates.

Two potential aquifer zones (shallow and deep) were targeted originally for characterization during the 1993 RI field activities. The 1994 field activities targeted shallow, intermediate, and deeper aquifer zones. The zones appear to exist as a singular aquifer unit

since no confining units were observed during the drilling of the monitoring wells. However, groundwater elevation and horizontal and vertical gradient data from the different zones provide information on each screened elevation.

Groundwater at the CSY was encountered generally at depths of approximately 15 feet BGS or less during drilling activities. Monitoring well hydrographs for water level elevations measured during the 1993 field season are provided in Appendix C. Changes in casing elevations were not observed during the 1994 field activities.

Wells AP-5509 and AP-5517, located upgradient and downgradient, respectively, of the CSY, were screened across the water table to provide information about the shallow aquifer. The water level trends (i.e., rising and falling water table) observed in these wells are consistent with fluctuations observed in USGS well 113, screened from 100 to 113 feet BGS, and other wells in the area. Monitoring wells 3595-01/3595-02/3595-03 were installed within the fenced storage yard and provide data on conditions near the coal pile. In 1993, water levels in these wells gradually increased through late summer until the end of the field season at the end of October. Elevations from AP-6142 (intermediate) and AP-6143 (shallow) represent conditions downgradient of the cooling pond. The water level elevation data show little change in elevation for the relatively short period of time during 1993, in which these wells were monitored.

6.1.3.1 Groundwater—Surface Water Interaction

Figure 6-3 represents groundwater elevations of CSY wells (AP-6142/AP-6143, 3595-01/3595-02/3595-03, and AP-5509/AP-5517). The data suggest that there is some interaction between surface water and groundwater, as described in Section 3. The elevation data show groundwater elevation fluctuations that correlate with the stage levels of the Chena and Tanana rivers. Groundwater fluctuations at the wells appear to lag behind peaks in the river stage data. This lag represents the time required for groundwater to flow through the aquifer system from the rivers for the monitoring wells. Fluctuations also could be caused by precipitation events, particularly from the relatively high amount of precipitation received during September (see Section 2), local pumping effects of the municipal and power plant wells, and recharge from the cooling pond.

Figure 6-3a represents the temperature of the groundwater during sampling activities. The cooling pond water is typically 25°C higher than the surrounding groundwater temperatures. This illustration suggests some surface water-groundwater interaction at the CSY.

6.1.3.2 Groundwater Flow Direction and Gradients

The groundwater elevation contours were generated for the shallow (i.e., groundwater interface) aquifer for 1993 data, and for the shallow and intermediate depth wells for 1994 data, as depicted in Figures 6-4, 6-5a, and 6-5b. No contours were generated for the deep zone since only two monitoring wells were screened at this depth. Intermediate and deep groundwater data were available only for 1994. Differences in groundwater elevations well pairs indicate the vertical gradient for the flow system, even though the aquifer may be a single aquifer unit. Locally, groundwater in the shallow aquifer in 1993 flowed to the north, within the vicinity of the active coal pile, and was incorporated into the regional northwesterly flow component. In 1994, the local shallow groundwater flow indicated a more northwesterly component flow direction. Groundwater data from the intermediate depth wells indicated groundwater flow in 1994 to the north-northwest. Groundwater in the deeper aquifer (as determined from only two deep wells) was estimated to flow to the west. The regional flow expected in the area for the alluvial aquifer unit is toward the Chena River. area.

The northern flow of shallow groundwater near the active coal pile may be influenced by the cooling pond or pumping from power plant supply wells. Power plant cooling water and drainage culverts discharging wastewater or precipitation runoff into the cooling pond may locally recharge the groundwater, having the effect of raising the static groundwater elevation. This would alter the groundwater flow direction in the vicinity of the cooling pond. As the groundwater table rises to the cooling pond level, groundwater flow would likely trend away from the cooling pond vicinity to later be incorporated into the regional flow direction. Drawings from the construction of the power plant indicated permafrost in soil borings drilled throughout the area. Depth to permafrost ranged from 12 feet to 33 feet BGS and extended to the total depth of each boring, approximately 60 feet BGS (Corps 1949). Absence of the permafrost during the RI is likely a result of the power plant activities and heat generation from the cooling pond.

Groundwater data for the intermediate wells show a fairly smooth and distinct northnorthwest flow direction. This aquifer zone flow may be influenced by a cooling pond and/or coal pile recharge component that also appears to affect the shallow zone flow direction, although the shallow aquifer shows a stronger northwest direction of flow in agreement with the regional flow direction.

It is not known whether cooling pond recharge and groundwater elevation mounding will affect the deeper aquifer zones, but some influence is likely. The deep aquifer data indicate a western flow direction, which is fairly consistent with the expected regional groundwater flow direction and may be influenced by the pumping of municipal wells directly to the west. A third deep well with the same screened interval is still needed to determine the exact flow direction, but this is not considered a critical data gap.

The average horizontal groundwater gradients across the CSY were calculated using groundwater elevations in the shallow and intermediate aquifer zones. The groundwater gradients were established between AP-6141 and AP-6143 in the shallow zone for 1993 data, and between AP-6141 and AP-6522 in the shallow zone for 1994 data, and between AP-6142 and AP-6519 in the intermediate zone. In the shallow aquifer, the horizontal groundwater gradient was calculated to be approximately 0.0025 (13.55 ft/mile) for the 1993 field season and approximately 0.0021 (10.6 ft/mile) for the 1994 field season. In the intermediate aquifer, the horizontal groundwater gradient was approximately 0.0024 (12.8 ft/mile) using the 1994 data. A horizontal gradient of approximately 0.003 (19.5 ft/mile) was calculated from only two wells, AP-6518 and AP-6521, in the deep aguifer using the 1994 groundwater elevation data. The shallow groundwater gradients for the 1993 period likely represent the seasonal high groundwater elevations because the data were collected near the end of the summer season with a significant increase in rainfall, as depicted in Figure 3-1. Shallow, intermediate, and deep groundwater gradients for the 1994 period likely represent the low- to mid-range groundwater elevations, based on past groundwater elevations in the Fort Wainwright area.

Wells 3595-01/3595-02/3595-03 are equipped with temperature and groundwater elevation probes to monitor long-term trends. Data collected from the three monitoring wells suggest that the operation of a pumping well (operated periodically during the year for two- to three-day durations) in Building 392 (located directly north of the CSY) has a northward effect on the direction of groundwater flow within the immediate area of the well (CRREL 1994). It is not known whether pumping of the Building 392 well affects other wells in the

CSY Source Area because no groundwater elevations that corresponded to the pumping period were measured.

A comparison of groundwater elevation data from monitoring wells AP-6142/ AP-6143, MW-1i/MW-1D, AP-6520/AP-6519/AP-6518, AP-6522/AP-6521, and AP-6524/AP-6523, which were completed at different depths, was performed to identify vertical groundwater gradients in the CSY Source Area. Vertical hydraulic gradients in AP-6142/ AP-6143 varied from approximately 0.007 to 0.048 feet downward from the shallow aquifer zone to the intermediate aquifer for groundwater elevations measured during the 1993 field season (see Figure 6-6). A gradient of 0.0015 feet upward was measured in AP-6142/ AP-6143 in the 1994 field season. The difference in the change from 1993 (downward) to 1994 (upward) data may reflect the amount of water recharging to the aquifer from the cooling pond. Vertical hydraulic gradients in AP-6520/AP-6519/AP-6518, measured from 1994 data, indicate a gradient of approximately 0.003 feet downward from the shallow aquifer zone to the intermediate aquifer zone and approximately 0.22 feet upward from the deep aquifer zone to the intermediate aquifer zone. This may be indicative of a highly conductive zone, between the shallow and deeper aquifer zones, in which groundwater flow is predominant and controls the area's groundwater flow patterns. A vertical gradient was measured in AP-6522/AP-6521 of approximately 0.012 upward from the deep aquifer zone to the shallow aquifer zone for 1994 field data. The vertical gradient measured in AP-6524/AP-6523 as approximately 0.005 downward from the shallow aquifer zone to the intermediate aquifer zone for 1994 data. The vertical gradients may coincide with the rise and fall of the Chena and Tanana river stages and represent recharge and discharge of the aquifer, diurnal and other time-dependent change, seasonal fluctuations, or pumping effects of nearby production and supply wells.

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6.1.3.3 Aquifer Testing

Previous investigations performed at Fort Wainwright have characterized aquifer properties, and, in general, the aquifers north and south of the Chena River are very transmissive. Because of the high transmissivity and the potentially large volume of contaminated water that would be generated, pump tests were not conducted during the RI. However, slug tests were performed at the CSY to confirm previous estimates of the hydraulic parameters of the underlying aquifer. Because the slug tests provide general aquifer

parameter information, specific aquifer performance values have not been obtained. This data gap, however, is not considered critical for the purposes of this RI/FS. The data generated from the slug tests were used to calculate hydraulic conductivity for the immediate area surrounding the well screen. Although the conductivity value determined may have been influenced by skin effects (the screen filter sand and formation smearing by the drilling bit), the conductivity is still a good estimate of the subsurface hydraulic properties.

The computer program GWAP (1987) was used to perform the Cooper *et al.* method (1967), while a Lotus 123 spreadsheet was used to manipulate the data for analysis using the Hvorslev method (1951). A copy of the aquifer testing data is provided in Appendix G.

Horizontal hydraulic conductivities calculated for the slug tests performed at shallow well AP-6143 indicate general low-range values of approximately 1.10 x 10⁻³ ft/second (95 feet per day [ft/day]) and high-range values of approximately 1.11 x 10⁻² ft/second (950 ft/day). A low-range value of transmissivity of approximately 35,000 gpd/ft and a high-range value of approximately 358,000 gpd/ft were calculated based on an assumed 50-foot saturated conductivity thickness. These values are within the expected range for a sand and gravel aquifer, and the low-range values are comparable to the results of previous investigations at Fort Wainwright.

6.1.3.4 Groundwater Travel Times

Darcy velocities were determined for the aquifer zones underlying the CSY. Values were calculated using an assumed effective porosity of 0.30 for a sand and gravel aquifer and the conductivity determined from slug tests. In addition, differences in head elevation between wells AP-5511 and AP-5517 for the 1993 field season and wells AP-6140 and AP-6522 for the 1994 field season data were used for the shallow aquifer zone, the differences in head elevation between AP-6142 and AP-6519 for the 1994 field data for the intermediate aquifer zone, and AP-6518 and AP-6521 in the deeper zone. The overall low-range velocity for the shallow and intermediate aquifer zones, which have approximately the same horizontal gradient across the CSY, was determined to be approximately 7.7×10^{-6} ft/second (243 ft/year) for 1993 and 1994 field season data. An overall high-range velocity for the shallow and intermediate aquifer zones was calculated to be approximately 9.25×10^{-5} ft/second (2,917 ft/year) for 1993 and 1994 field season data. A low-range velocity for the deeper aquifer zone of approximately 1.1×10^{-5} ft/second (347 ft/year) and a

high-range velocity of approximately 1.11×10^{-4} ft/second (3,500 ft/year) were calculated for the deeper aquifer 1994 data. These deeper aquifer zone data may not be representative of site conditions since gradients were established only between two monitoring wells. The groundwater flow velocities are presented as an estimation of groundwater flow across the CSY Source Area and may not represent the actual movement processes occurring.

6.1.3.5 Hydrogeochemistry

Chemical analyses, including cation and anion analysis of groundwater, was performed at the CSY to characterize the chemistry of the underlying aquifer and to provide insight into surface water and groundwater interactions and contaminant fate and transport studies. An evaluation of the general groundwater chemistry in the immediate vicinity of the CSY Source Area for wells AP-6142/AP-6143, AP-6141, and 3595-01/3595-02/3595-03 was completed using Stiff and Piper diagrams as a characterization tool (see Figure 6-7). Stiff diagrams are used to provide information on areal trends that may exist in an area, while Piper diagrams give an indication of chemical trends that may exist. A general mass balance for the groundwater samples from the monitoring wells also was calculated for the cations and anions determined from laboratory analysis; a hard copy of forms of the hydrogeochemical data is provided in Appendix D.

The criteria for groundwater samples submitted for geochemical analysis, where the pH is less than 6 and the mass balance of cations to anions is over 5%, are considered unusable for evaluation. This is because of the limiting geochemical reactions, including the results being inaccurate; other constituents being present that are not used in the balance; or organic ions not present in significant quantities. Based on analysis, data from AP-6143 and 3595-01 did not meet a cation/anion balance of less than 5% and data from 3595-01/3595-02/-3595-03 had a pH of less than 6 (pH ranged from 5.2 to 5.9). The pH data may be biased because of calibration or equipment variances of hand-held pH meter readings; however, all well data from these wells should be used with caution. The data indicate that an ion may be missing from the balance calculation and/or that influences from the coal pile, cooling pond, or contaminant sources could be affecting the pH values or ionic balance of the groundwater samples. The anomalous pH readings, however, do not affect the intent of comparing aquifer cation and anion chemistries.

An examination of the Stiff and Piper diagrams indicates that there is an areal difference in water samples collected from near the CSY Source Area from those collected upgradient and downgradient of the coal pile area but that there is not much of a chemical trend in the groundwater samples. The areal differences may be due to elevated cooling pond temperatures, coal and groundwater chemical interaction, or the presence of elevated COPCs.

A comparison of chemical analyses of the Chena River surface water samples from SD-10 and SD-14 locations and CSY Source Area wells shows that no discernable variations exist between the surface water samples and the groundwater samples. An areal comparison of Stiff diagrams between CSY wells AP-6142, AP-6143, and AP-6141 and FTP wells (discussed in Section 7), both completed in the Chena and Tanana rivers alluvium, indicates that slight similarities exist between the source areas, which may be indicative of the alluvial flow system.

6.1.3.6 Groundwater Turbidity

Turbidity was measured at the time of groundwater sampling but was not used as a criterion for well development, as approved in the MP (E & E 1993a). The turbidity values measured at wells across the fort historically have yielded from low to very high turbidity. The sampled values of turbidity and the groundwater sample photographs (see Appendix D) were reviewed for potential turbidity trends geographically.

An areal comparison of turbidity values measured at shallow monitoring wells at the CSY indicates that values generally are higher away from the cooling pond, particularly near the drum storage area and north of the power plant. Two of the wells within the drum storage area (3595) exhibited turbidity values exceeding 200 NTUs, and AP-5517 exceeded 100 NTUs. No inferences on the effect of the cooling pond on turbidity can be drawn because of the variables that can affect turbidity.

6.1.4 Ecology of the Coal Storage Yard Source Area

The Ecological Risk Assessment (ERA) contains a thorough review and evaluation of the ecology at the CSY Source Area. The following description summarizes those findings.

The CSY is unvegetated and is bordered by forest and shrub uplands and barren disturbed areas. A small vegetated hill lies on the east side of the CSY, separating it from another industrialized area. A power plant is on the north side. The CSY is separated from

the cooling pond by a gravel road and a narrow strip of young deciduous trees. The cooling pond is bordered by an upland forest to the south and west. The area north of the cooling pond and power plant is vegetated with grasses and is regularly mowed.

The vegetated areas south and southeast of the CSY, and south and west of the cooling pond, represent a potential habitat for bird and mammal populations. Waterfowl use the cooling pond for resting, foraging, and potentially nesting. No fish inhabit the cooling pond. Ducks were observed in the cooling pond during the field investigation.

6.2 NATURE OF CONTAMINATION AT THE COAL STORAGE YARD

This section summarizes analytical results by media generated during the 1993 and 1994 field seasons at the CSY Source Area. An overview of the nature of contamination is followed by discussion of extent, or spatial distribution, of contamination. A complete list of the analytical results is provided in Appendix I. Within each media, inorganic results are discussed separately from organic compounds. Within the organic results discussion, field laboratory results are discussed first, followed by petroleum-related compounds, VOCs, and pesticides. Many samples collected at the CSY were analyzed in the field laboratory. The analytical results were used to make field decisions, such as determining where further sampling was needed or locating boreholes or wells. The field analytical results are presented in this section for the sake of completeness; however, they were not used to determine COPCs. To assist in putting the nature and extent of contamination into a human health perspective, each discussion also includes those chemicals considered to be COPCs at the CSY. An overview of the procedure for selection of COPCs follows.

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A conservative risk-based screening procedure was used to select COPCs at the CSY. This screening procedure was identical to that used for the OU-4 Baseline Human Health Risk Assessment, which was amended from the screening procedure used in the Approach Document for the Baseline Human Health Risk Assessment (E & E 1994) based on the availability of updated toxicity information and comments received from the Corps, ADEC, and EPA. The Approach Document identified those compounds that pose a potential risk to human health. The RI builds on this information by providing more detail on the nature and extent of these compounds at each OU-4 source area. The Baseline Human Health Risk Assessment quantitates the risks posed by those compounds and further defines those that potentially pose a substantial risk to the public. Chemicals detected at the CSY were screened

against RBCs for residential soil and drinking water derived from EPA, Region 3, guidance (EPA 1994a). EPA, Region 10, specifies the use of this guidance for screening purposes (EPA 1994d) because it reflects the most current toxicity available criteria. EPA's current action level for lead in drinking water of 15 μ g/L (EPA 1991) and EPA's updated lead in soil screening concentration of 400 mg/kg also were used for this screening process (EPA 1994e).

To be conservative, chemicals detected in surface soil, subsurface soil, ash, and sediment were compared to the RBC equivalent to a 1×10^{-7} excess cancer risk, or a hazard quotient of 0.1. All chemicals detected in groundwater and surface water were compared to the RBC equivalent to a 1×10^{-6} excess cancer risk, or a hazard quotient of 0.1. Chemicals exceeding one or both of these criteria were considered to be COPCs. State of Alaska Water Quality Standards (18 AAC 70) and MCLs (18 AAC 80) have been included in the analytical tables only for the sake of comparison because ARARs have not been established for the source area. Table 6-3 lists the RBCs for analytes detected at the CSY.

Since RBCs are unavailable for petroleum products, petroleum contamination in soil was compared to values in the cleanup matrix scoresheet from the *Interim Guidance for Non-UST Contaminated Soil Cleanup Levels*, Guidance No. 001, Revision No. 1, July 17, 1991 (ADEC 1991). DRO and GRO analyses were not conducted for every sample. For those samples that do not have DRO or GRO results, the results of the fuel ID analysis were compared to the matrix values that would be quantitated analytically in similar ranges. Bunker C-range organics were compared to the value for residual-range petroleum hydrocarbons because, analytically, they would be quantitated within that range. The State of Alaska does not have a specific cleanup level for petroleum in water but does not allow the presence of a visible sheen, discoloration or film, or odor or taste, according to organoleptic tests. These tests were conducted; therefore, it was assumed that if petroleum hydrocarbons were detected in water, they were COPCs.

Inorganics were eliminated as COPCs if they were present at naturally occurring (i.e., background) concentrations at OU-4. First, concentrations were compared to the Corps-recommended background data for arsenic, barium, cadmium, chromium, and lead in soil and groundwater because these values have been established statistically (Corps 1994) and are presented in Table 3-3. Sample results then were compared to the maximum detected background concentration in each environmental medium at each source area. Background samples were collected from locations believed to be unaffected by site-related contaminants

because of their upgradient locations and distance from known or suspected contamination sources. Inorganics for which Corps-recommended background values and RBCs were not available were compared to the range of concentrations of these elements in Alaska soils (Gough 1988).

Aluminum, calcium, iron, magnesium, potassium, and sodium were eliminated from the nature and extent of contamination discussions because they are not associated with toxicity to humans under normal circumstances. However, in several instances, the maximum detected concentration of aluminum exceeded background concentrations by more than three times. At that point, the concentration of aluminum was compared to the normal range of aluminum in Alaska soils (Gough 1988).

Any chemical existing at concentrations even approaching a potential risk to human health was identified using this conservative screening approach. A more detailed description of the human health risk-based COPC screening procedure is presented in the OU-4 Baseline Human Health Risk Assessment.

Table 6-3 lists the RBCs and source area-specific background concentrations used for comparison purposes.

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6.2.1 Nature of Surface Soil Contamination

Surface soil samples were collected from five locations, including one background location, at the CSY using procedures described in Section 2. Blind duplicate samples were collected at two of the five locations. Table 6-4 lists the analytes detected in surface soils.

6.2.1.1 Inorganic Results

Inorganic elements detected at all sampling locations at concentrations less than the risk-based screening concentrations include chromium, copper, lead, nickel, and zinc. However, chromium was detected above the Corps-recommended background concentration. Mercury, detected in one sample, and silver, detected in two samples, were found at levels below the RBCs. Copper, mercury, nickel, and silver were detected at concentrations exceeding background sample concentrations. Cobalt was detected above the background sample concentration but was within the normal range for cobalt in Alaska soils (2 to 55 mg/kg; Gough 1988). No RBC exists for cobalt.

Aluminum was detected at all surface soil sample locations, at concentrations ranging from 6,220 to 44,100 mg/kg. The background surface soil sample contained 8,630 mg/kg aluminum. One sample was approximately five times the background sample concentration. No RBC for aluminum exists. However, the concentration of aluminum is within the normal range for Alaska soils (12,000 to 120,000 mg/kg; Gough 1988).

Arsenic was detected in all surface soil samples, at concentrations ranging from 2.4 to 11.8 mg/kg. Although all samples exceed the RBC of arsenic (0.037 mg/kg), none exceed the Corps-recommended background concentration of 14 mg/kg for soils south of the Chena River.

Barium was detected in all CSY surface soil samples, at concentrations ranging from 79 to 2,630 mg/kg. The background sample concentration and the Corps-recommended background value for barium for soils south of the Chena River are 115 mg/kg; samples from three locations exceeded this concentration. The sample from one location exceeded the RBC for barium (550 mg/kg).

Beryllium was detected in all CSY surface soil samples, at concentrations ranging from 0.32 to 2.2 mg/kg. The background sample contained 0.43 mg/kg beryllium. There is no Corps-recommended background value for beryllium. The samples from three locations exceeded the background sample concentration. Samples from all locations exceeded RBCs (0.015 mg/kg).

Cadmium was detected in three of the eight surface soil samples, at concentrations ranging from 0.54 to 54 mg/kg. One sample location exceeded the Corps-recommended background concentration of 1.8 mg/kg and the RBC of 3.9 mg/kg.

Manganese was detected in all the surface soil samples, at concentrations ranging from 134 to 572 mg/kg. Samples from four locations contained manganese at concentrations exceeding the background sample concentration of 184 mg/kg. There is no Corpsrecommended background concentration for manganese. All samples exceeded the RBC of 39 mg/kg for manganese.

Selenium was detected in one surface soil at 52 mg/kg, which exceeds the RBC of 39 mg/kg. The background sample did not contain selenium above the detection limit of 0.28 mg/kg. There is no Corps-recommended background value for selenium.

Vanadium was detected in all CSY surface soils, at concentrations ranging from 25.8 to 112 mg/kg. One sample contained vanadium at a concentration exceeding the

background sample concentration of 35.3 mg/kg. One sample contained vanadium at concentrations exceeding the RBC (55 mg/kg).

Based on the screening criteria, barium, beryllium, cadmium, manganese, selenium, and vanadium are the inorganic COPCs for surface soils.

6.2.1.2 Organic Results

Table 6-4 presents the organic compounds detected in surface soils by the project laboratory. All samples were analyzed for fuel ID and TRPH, which includes diesel, lubricating oils, and heavy-end hydrocarbons. TRPH was detected in seven samples, at concentrations ranging from 25.7 to 4,760 mg/kg, with the background sample having the lowest concentration. Bunker C-range organics were detected at all locations at concentrations ranging from 53 to 3,400 mg/kg. The background sample contained the lowest concentration. Diesel was detected in two samples, at concentrations ranging from 25 to 270 mg/kg. One duplicate sample was analyzed for DRO and GRO. GRO was detected at an estimated 1.2 and 1.4 mg/kg, and DRO at 1,000 and 1,500 mg/kg. The levels of DRO and diesel exceed the State of Alaska Levels A, B, and C cleanup matrix standards. The highest concentrations of bunker C-range organics exceed the State of Alaska cleanup standard of 2,000 mg/kg for residual-range petroleum hydrocarbons.

FSPH and FSVOC analyses were performed on the eight surface soil samples. FSPH results ranged from nondetected (21 mg/kg) to 74 mg/kg. FSVOC analysis detected o-xylene and tetrachloroethene in one sample at 6.8 and 18.0 μ g/kg, respectively (see Table 6-5).

One surface soil sample contained 1,2,3,4,6,7,8-HpCDD at 86.6 pg/g and 1,2,3,6,-7,8-HxCDD at 4.39 pg/g, exceeding the RBCs of 41 pg/g and 4.1 pg/g, respectively.

Surface soil samples also were analyzed for BNAs, PCBs, and herbicides; none were detected. Pesticides and VOCs were detected, but none were present at concentrations exceeding risk-based screening concentrations. Therefore, the organic compounds retained as COPCs in surface soils at the CSY are fuels, because they potentially exceed State of Alaska cleanup matrix standards, and 1,2,3,4,6,7,8-HpCDD; 1,2,3,6,7,8-HxCDD.

6.2.2 Nature of Subsurface Soil Contamination

Subsurface soil samples were collected from 14 locations, including one background location. Thirty samples, including duplicate samples, were collected from the boring

locations. A summary of detected constituents is presented in Table 6-4. Duplicate analysis was not run for every parameter when a duplicate was collected, which is why the number of samples analyzed varies in Table 6-4.

6.2.2.1 Inorganic Results

Aluminum concentrations ranged from 3,650 to 24,200 mg/kg. Samples from one borehole exceeded four times the background sample concentration of 4,680 mg/kg. No RBC or Corps-recommended background value exists for aluminum. However, the range of aluminum concentration is within the normal range for Alaska soil (12,000 to 120,000 mg/kg; Gough 1988).

Barium concentrations ranged from 45.7 to 1,230 mg/kg. Barium concentrations exceeded the RBC of 550 mg/kg at one subsurface sample location. This location and an additional location exceeded the Corps-recommended background concentration of 115 mg/kg.

Beryllium concentrations ranged from 0.19 to 1.2 mg/kg in subsurface soils. Beryllium was detected in the background borehole, at 0.27 mg/kg and 0.25 mg/kg, at different depths. Eight subsurface samples exceeded this concentration. All subsurface samples exceeded the RBC for beryllium (0.015 mg/kg).

Chromium was detected at concentrations ranging from 7.9 mg/kg to 40 mg/kg in all subsurface soil. The collected background sample concentrations were 11.8 mg/kg and 8.8 mg/kg. Four samples exceeded the Corps-recommended background concentration of 19 mg/kg. One sample also exceeded the RBC of 39 mg/kg.

Cobalt was detected in all subsurface soil, at concentrations ranging from 3.1 to 16.9 mg/kg. No Corps-recommended background value or RBC exists for cobalt. The range of cobalt concentrations are within the normal range for Alaska soil (2 to 55 mg/kg; Gough 1988).

Manganese concentrations in subsurface soils ranged from 80.7 to 413 mg/kg, all exceeding the RBC of 39 mg/kg. The background sample contained 189 mg/kg at 19 feet BGS. Nine locations had subsurface samples, with manganese concentrations in excess of 189 mg/kg.

Vanadium concentrations in subsurface soils ranged from 13.6 to 73.3 mg/kg. Sample concentrations from the background borehole were 20.3 and 20.9 mg/kg. One sample

location exceeded the RBC of 55 mg/kg. Samples from 12 locations contained vanadium at concentrations exceeding the highest background sample concentration.

In summary, the inorganic COPCs for CSY subsurface soils include barium, beryllium, chromium, manganese, and vanadium.

6.2.2.2 Organic Results

FSPH and FSVOC analyses were performed on 54 subsurface samples at the CSY. FSPH was detected in 21 subsurface soil samples, in concentrations ranging from 20 to 200,000 mg/kg. FSVOC analytical results are summarized in Table 6-5.

Fuel ID and TRPH analyses were performed by the project laboratory on all subsurface samples collected from the CSY. TRPH was detected in 17 samples from eight boreholes, ranging in concentration from 9.1 to 60,000 mg/kg. Bunker C-range organics were detected in nine samples from five locations, ranging in concentration from 69 to 35,000 mg/kg. Diesel was detected in seven samples, at concentrations ranging from 5.1 to 5,900 mg/kg. DRO also was analyzed from a duplicate sample, with results of 25 and 39 mg/kg. Kerosene was detected in one sample, at a concentration of 32 mg/kg. The highest concentrations of diesel exceed the State of Alaska cleanup matrix standards for all levels. Bunker C-range organics in two boreholes exceed the State of Alaska cleanup standard of 2,000 mg/kg for residual-range hydrocarbons.

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The compound 1,3,5-trimethylbenzene was detected in four subsurface soil samples, at concentrations ranging from 0.023 to 9 mg/kg. One sample exceeded the RBC of 3.1 mg/kg. The benzene concentration at one location (14 mg/kg) exceeded the RBC of 2.2 mg/kg. The benzene concentration in one borehole exceeded all the State of Alaska level matrix cleanup values for benzene. In addition, the combined BTEX value in these samples also exceeds all the State of Alaska matrix cleanup values for BTEX.

In addition, 4,4'-DDT was detected in six subsurface soil samples at concentrations ranging from 0.002 to 0.23 mg/kg. One sample contained 4,4'-DDT at a concentration exceeding the RBC of 0.19 mg/kg.

Subsurface samples also were analyzed for BNAs, herbicides, PCBs, and dioxins/furans; no herbicides were detected. In one location, Aroclor 1260 was detected at concentrations of 0.0052 mg/kg and 0.025 mg/kg, respectively, at 19 feet and 14 feet BGS. One sample exceeded the RBC of 0.0083 mg/kg. The BNAs and dioxins/furans were

detected at concentrations less than the RBC. The organic COPCs for CSY subsurface soils include Aroclor 1260; benzene; BTEX; diesel; bunker C-range organics; 1,3,5-trimethylbenzene; and DDT.

6.2.3 Nature of Sediment Contamination

Sediment samples were collected from 10 locations, including one background location. One duplicate sample was collected for a total of 11 sediment samples collected at the CSY. Table 6-6 lists the inorganic and organic constituents detected in sediments at the CSY.

6.2.3.1 Inorganic Results

Aluminum and cobalt were detected above background values; however, they were within the ranges for those elements in Alaska soils (Gough 1988).

Arsenic was detected in 10 samples, nine different sample locations, at concentrations ranging from 1.4 to 31.1 mg/kg. One sample exceeded the Corps-recommended background value of 14 mg/kg for arsenic in soils south of the Chena River. All samples exceeded the RBC of 0.037 mg/kg.

Chromium was detected in all sediment samples, at concentrations ranging from 7.8 to 48.9 mg/kg. Samples from four locations exceeded the Corps-recommended background value of 19 mg/kg for chromium in soils south of the Chena River. One sample location exceeded the RBC of 39 mg/kg for chromium.

Copper was detected in all sediment samples, at concentrations ranging from 23.7 to 26,700 mg/kg. All sample locations contained copper concentrations greater than the background sample concentration of 20.7 mg/kg. No Corps-recommended background concentration for copper exists. Two locations exceeded the copper RBC of 290 mg/kg by 10 times or greater.

Mercury was detected in five sediment samples, at concentrations ranging from 0.14 to 4.2 mg/kg. Concentrations in the background sample did not exceed the detection limit of 0.89 mg/kg. Concentrations in one sample exceeded the RBC of 2.3 mg/kg.

Barium, beryllium, manganese, and vanadium were detected at concentrations similar to those found in surface and subsurface soils exceeding background concentrations and RBCs. They also were retained as COPCs in sediments.

Therefore, the inorganic COPCs for CSY sediments include arsenic, barium, beryllium, chromium, copper, manganese, mercury, and vanadium.

6.2.3.2 Organic Results

Neither FSPH or FSVOC analyses were performed on CSY sediment samples. All sediments were analyzed by the off-site laboratory for TRPH and fuel ID. TRPH was detected at four locations, in concentrations ranging from 39.4 to 627 mg/kg. Bunker C-range organics were detected at four locations, in concentrations ranging from 43 to 640 mg/kg. Two samples were analyzed for DRO. DRO was detected at concentrations ranging from 6.5 to 8.9 mg/kg. None of these concentrations are likely to exceed the State of Alaska matrix cleanup levels.

Six PAHs were detected in two sediment locations, at concentrations exceeding the RBC. The compounds of concern are benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. Numerous other PAH compounds also were detected at these two locations but below RBCs.

All other detected organic compounds (VOCs and dioxins) were detected at less than RBCs and, therefore, will not be considered COPCs. In summary, the organic COPCs in sediments at the CSY are the six PAHs mentioned above.

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6.2.4 Nature of Surface Water Contamination

The inorganic and organic constituents detected in the two samples collected from the cooling pond surface water are listed in Table 6-7. Inorganics were compared to the Alaska Water Quality Criteria (18 AAC 70) and the Alaska Drinking Water Standards (18 AAC 80) for many inorganics. Both samples contained dissolved manganese above the secondary MCL of 0.05 mg/L. One sample also contained iron exceeding its secondary MCL of 0.3 mg/L and zinc above the ambient water quality criteria of 0.047 mg/L. Only the level of arsenic exceeds its RBC; however, the level of arsenic did not exceed background values for groundwater.

Methylene chloride was the only organic compound detected. It was found in one of the surface water samples at 11 μ g/L, which exceeds the RBC of 4.1 μ g/L and the MCL of 5

 μ g/L. Methylene chloride also was detected in laboratory blanks. Methylene chloride is being retained as a COPC.

6.2.5 Nature of Groundwater Contamination

Eighteen groundwater samples were collected from the CSY area during the 1993 field season. Table 6-8 lists the constituents detected. Constituents detected from the 1994 sampling event are summarized in Tables 6-9 through 6-14.

6.2.5.1 Inorganic Results

Because the RBCs and, consequently, the COPCs, are based on the dissolved metals concentrations, only the dissolved results are discussed.

In 1993, dissolved antimony was detected in five groundwater samples, at concentrations ranging from 26 to 37 μ g/L, which exceeds the background concentration, RBC, and MCL. The background sample contained antimony at 12.5 μ g/L. The RBC is 1.5 μ g/L, and the primary MCL is 6 μ g/L (18 AAC 80). The Alaska Water Quality Criterion for antimony is 1,600 μ g/L (ADEC 1991b).

In 1993, dissolved iron ranged in concentration from 75 μ g/L to 15,900 μ g/L in groundwater samples. The secondary MCL for iron is 300 μ g/L (18 AAC 80) and the Alaska Water Quality Criterion is 1,000 μ g/L (ADEC 1991b). No RBC exists for iron.

In 1993, dissolved manganese was detected in all of the groundwater samples, at concentrations ranging from 60 to 920 μ g/L. The background sample contained manganese at 780 μ g/L. All groundwater samples exceeded the RBC of 18 μ g/L for manganese, and the secondary MCL of 50 μ g/L (18 AAC 80). No Alaska Water Quality Criterion exists for manganese.

In 1994, dissolved arsenic concentrations ranged from 0.94 μ g/L to 13 μ g/L (see Table 6-13). All samples exceed the RBC of 0.038 μ g/L but not the MCL and water quality criterion (50 μ g/L) and the Corps-recommended background value of 18 μ g/L. No other inorganics detected in the 1994 sampling event exceeded their respective RBC.

Antimony, iron, and manganese were retained as COPCs in groundwater at the CSY.

6.2.5.2 Organic Results

FSPH analysis was performed on 51 groundwater samples collected using the Geoprobe[™]. FSPH was detected in 16 samples; results ranged in concentration from 2.6 to 54 mg/L. FSVOC analysis was performed on 103 groundwater samples collected during the Geoprobe[™] and MicroWell investigations. The results for the FSVOC groundwater samples were presented in Table 6-5.

Organic compounds detected by the project laboratory in the groundwater at the CSY are listed in Table 6-8. TRPH was detected in 11 wells in the CSY, at concentrations ranging from 250 to 2,000 μ g/L. One background well (AP-5734) contained TRPH at 580 μ g/L. Bunker C-range organics were detected in nine wells at concentrations ranging from 390 to 1,100 μ g/L. Diesel also was detected in one well, at 310 μ g/L. No RBCs exist for fuel; however, the State of Alaska Water Quality Criteria (18 AAC 70) stipulates that petroleum hydrocarbons cannot cause a visible sheen on the surface of a drinking water source.

Pesticides detected in groundwater include dieldrin, heptachlor, heptachlor epoxide, and methoxychlor. The methoxychlor concentrations did not exceed its RBC. Dieldrin was detected in two samples at 0.01 and 0.021 μ g/L, exceeding the RBC of 0.0042 μ g/L. No MCL or water quality criterion exists for dieldrin. Heptachlor was detected in one groundwater sample at 0.08 μ g/L, exceeding the RBC of 0.0023 μ g/L and the water quality criterion of 0.0038 μ g/L, but not the MCL of 0.2 μ g/L (18 AAC 80). Heptachlor epoxide was detected in two groundwater samples, at concentrations of 0.01 and 0.02 μ g/L, exceeding the RBC of 0.0012 μ g/L but not the MCL of 0.2 μ g/L (18 AAC 80). No water quality criterion exists.

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VOCs and BNAs were detected in groundwater samples. TCE was detected in two samples, at concentrations of 7 μ g/L and 56 μ g/L, both exceeding the MCL and water quality criterion of 5 μ g/L (18 AAC 80). Methylene chloride and bis(2-ethylhexyl)phthalate were detected in two and four samples, respectively, at concentrations exceeding the RBCs. The highest concentration of methylene chloride was 6 μ g/L, and the highest concentration of bis(2-Ethylhexyl)phthalate was 110 μ g/L. Although these are common laboratory contaminants, the concentrations are too high to be attributed to laboratory contamination.

The MicroWell samples were collected at different depths beneath the coal pile and were analyzed for VOCs only by the project laboratory. The VOCs detected include BTEX compounds and chlorinated compounds (see Table 6-19 and Table 6-20). Benzene concentrations exceeded the MCL of 5 μ g/L at three depths in a microwell within the active coal pile.

TCE was detected in six samples collected from three locations, but all concentrations were less than the MCL of 5 μ g/L. All toluene and xylene results were less than the MCLs for those compounds. However, concentrations of BTEX at two MicroWell locations exceeded the new water quality standard of 10 μ g/L. Benzene; cis-1,2-dichloroethene; xylenes; ethylbenzene; and toluene were detected at concentrations exceeding RBCs.

Trichlorofluoromethane was the only VOC detected that exceeded its RBC. Fuels were detected in three wells; fuel ID analysis revealed a concentration of 140 μ g/L diesel in one well. DRO was detected in three wells, ranging in concentration from less than 100 to 320 μ g/L. TRPH was detected in two wells, at a concentration of 250 μ g/L. Pesticides were detected in one well. The concentrations of dieldrin and heptachlor exceeded their RBCs. There is no RBC for endrin ketone; however, its concentration was less than the RBC for endrin.

Several dioxin congeners were detected in groundwater from samples collected in 1993 and 1994. The compounds 1,2,3,7,8-PeCDD; 1,2,3,4,7,8-HxCDD; 2,3,4,7,8-PeCDF; 1,2,3,6,7,8-HxCDF; 1,2,3,4,6,7,8-HpCDD; 2,3,7,8-TCDD; 2,3,7,8-TCDF; 1,2,3,6,7,8-HpCDF; 1,2,3,4,7,8-HxCDF; 1,2,3,7,8,9-HxCDD; 1,2,3,7,8,9-HxCDF; 1,2,3,6,7,8-HxCDD; and 2,3,4,6,7,8-HxCDF were detected above RBCs and retained as COPCs (see Table 6-15).

BNAs detected in the 1994 sampling event are common laboratory contaminants; however, the concentration of bis(2-ethylhexyl)phthalate exceeds its RBC.

Based on the risk-based screening of 1993 and 1994 data, benzene; bis(2-ethyl-hexyl)phthalate; cis-1,2-dichloroethene; dieldrin; ethylbenzene; heptachlor; heptachlor epoxide; methylene chloride; toluene; trichlorofluoromethane; TCE; xylenes; fuels; and several dioxin congeners are organic COPCs in groundwater at the CSY.

6.3 EXTENT OF CONTAMINATION

The extent of contamination at the CSY Source Area is discussed in the following section. The determination of extent is based on project laboratory and field laboratory sample results, although field laboratory results were used mainly to provide a guide for further sampling. Sample locations were, to some extent, adjusted in the field on the basis of obvious areas where contamination likely would accumulate. Active operations at the CSY

limited the areas from which samples could be obtained. As a result, the extent of contamination in certain media could not be determined definitively.

Table 6-16 lists the analytes exceeding RBCs or background concentrations. Groundwater contamination was determined from both monitoring wells installed and sampled in 1993 and 1994, along with existing wells around the CSY.

6.3.1 Extent of Surface Soil Contamination

Inorganic contamination in surface soil is greatest in two apparent hot-spots, AP-6159 and AP-6162. Of the six surface soil sampling locations, one location (AP-6159), southeast of the CSY, exceeded background and/or RBCs for barium, beryllium, manganese, selenium, and vanadium. Samples from AP-6162 contained beryllium, cadmium, and manganese at concentrations that exceeded background and/or RBCs (see Figures 6-8).

AP-6159 is located in a vegetated area across an unnamed road from the southern-most coal pile. Since the inorganic contamination at this location has higher concentrations of barium, beryllium, selenium, and vanadium than any other location at the CSY, this contamination may be attributable to a source other than the CSY.

AP-6162 is in an active area of the CSY, in which former USTs and other equipment have been stored. Given that the ground surface is scraped annually, the contamination detected is probably related to recent activities rather than historic practices at the CSY.

There is no apparent geographic pattern to the distribution of inorganic contamination in surface soils, which eliminates wind and surface water as significant contaminant migration pathways. Many contaminants were found in background samples, suggesting that there are other potential contaminant sources or that the area surrounding the CSY has naturally occurring higher levels of these inorganics than other parts of the fort. With the data available, it is not possible to determine whether the metals discussed above are contaminants attributable to the CSY, with the exception of manganese. The overall highest levels of manganese are associated with the active coal pile and the fenced storage area. The overall extent of the manganese contamination at the CSY was not defined because all surface soil samples collected exceed the RBC.

As discussed in Section 6.2.1, fuels are the organic COPCs for surface soils. Bunker C-range organics were detected at all sample locations. TRPH was detected at all locations, except AP-6159. One surface soil sample was analyzed for DRO and GRO (AP-6158); both

analytes were detected. The highest concentration of petroleum hydrocarbon was detected beneath the coal pile at the ground surface (4,760 mg/kg TRPH, 3,400 mg/kg bunker C-range organics, and 270 mg/kg diesel). Figure 6-10 illustrates petroleum-related compound distribution in surface soils. Concentrations of diesel, DRO, or bunker C-range organics exceeding the State of Alaska Levels A and B cleanup values and the cleanup standard for residual-range petroleum hydrocarbons are limited to the active coal pile and AP-6158, located west of the emergency coal pile.

The petroleum contamination detected in the background samples, in contrast to the inorganic contamination, may be the result of contaminant migration via surface water. However, the contamination found at AP-6141 probably is related to road activities. In general, petroleum-related contamination is widespread in surface samples, with hot-spots of higher contamination. The exact extent of contamination exceeding the State of Alaska cleanup level matrix cannot be determined, but it appears to be limited to areas immediately adjacent to or underneath the coal piles.

6.3.2 Extent of Subsurface Contamination

6.3.2.1 Inorganic Results

Like surface soils, inorganic contamination in subsurface soils appears to be randomly disturbed with isolated hot-spots (see Figure 6-9). Elevated concentrations of aluminum, barium, beryllium, and vanadium were detected in the subsurface soils. These elevated concentrations appear to be randomly distributed under the active coal pile, the fenced storage yard, and the railroad tracks. Given the random distribution of the contamination, its origin appears to be leaching and not the result of migration via groundwater.

AP-6159, located south of the emergency coal pile, was the only location containing concentrations of aluminum, barium, beryllium, and vanadium that exceeded background concentrations and RBCs. As discussed in the surface soil section, this contamination is probably not attributable to historic activities at the CSY, but is more likely the result of a different source. Since groundwater flows to the northwest, this contamination cannot be the result of groundwater migration from the CSY.

Manganese concentrations at all locations exceeded RBCs, including at background locations. The elevated manganese levels generally are found in the vicinity of the coal piles and the fenced storage yard, and adjacent to the power plant. Alaska surface soils can exhibit

concentrations of manganese within the range of 999 mg/kg to 1,313 mg/kg (Los Alamos National Laboratory, 1983). Elevated levels of beryllium and vanadium also were detected in these locations.

6.3.2.2 Organic Results

Petroleum-related contamination is widespread across the CSY (see Figure 6-11). The highest concentrations of TRPH (60,000 mg/kg), bunker C-range organics (35,000 mg/kg), and diesel (5,900 mg/kg) were detected beneath the coal pile, at a depth of approximately 15 feet BGS. These levels of contamination exceed all State of Alaska cleanup matrix levels. The concentrations in the same boring at 27 feet BGS were 3,500 mg/kg of TRPH, 4,800 mg/kg bunker C-range organics, and 320 mg/kg diesel. The deepest sample containing TRPH was at AP-6165, which contained TRPH at 141 mg/kg, bunker C-range organics at 65 mg/kg, and diesel at 6.3 mg/kg, at approximately 31 feet BGS.

In general, TRPH, bunker C-range organics, and diesel concentrations decreased with depth, and with distance from the coal pile. Concentrations of TRPH in the fenced storage yard ranged from 60 to 160 mg/kg at 9 to 19 feet BGS, bunker C-range organics ranged from 69 to 380 mg/kg, and diesel ranged from 62 to 360 mg/kg over the same depths. This contamination exceeds State of Alaska matrix cleanup Levels A and B. The extent of petroleum contamination exceeding State of Alaska cleanup guidelines is limited to the coal pile and the fenced storage yard. Bunker C-range organics were detected in the background samples and in one sample between the active and emergency coal piles. Since the groundwater gradient is to the northwest, the bunker oil contamination in the background samples is probably attributable to sources other than the CSY.

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The compound 1,3,5-trimethylbenzene was detected in three borings, two between the fenced storage yard and the active coal pile, and one beneath the active coal pile (see Figure 6-12). The highest concentration was detected beneath the coal pile, at approximately 11 feet BGS. This compound was detected at 19 feet BGS in AP-6167 and AP-6168. The 1,3,5-trimethylbenzene contamination appears related to the fuel application on the coal pile. Aroclor 1260 also was detected at 14 feet and 19 feet BGS in borehole AP-6167. This contamination also may be related to the application of used oil and fuel to the coal pile. The area of concern is the soils beneath the coal pile to depths of approximately 20 feet BGS.

The compound 4,4'-DDT was detected in subsurface soils at six locations. AP-6166, northwest of the coal pile, contained this compound at 0.230 mg/kg at 14 feet BGS. At the same location at 19 feet BGS, the 4,4'-DDT concentration was at 0.004 mg/kg, and the 4,4'-DDT contamination is not considered to be a result of a particular source or practice at the CSY.

6.3.3 Extent of Sediment Contamination

Although most sediment samples collected in the cooling pond contained slightly elevated concentrations of metals (arsenic, barium, beryllium, chromium, copper, manganese, mercury, and vanadium), a sample collected from the west side of the cooling pond and from the east side of the dock contained metals at concentrations greater than three times the background concentrations and/or RBCs. These samples also contained the highest concentration of TRPH and bunker C-range organics (see Figures 6-8 and 6-10). Two sediment samples collected at the dock in the cooling pond contain six polycyclic aromatic hydrocarbons at concentrations exceeding RBCs. Sediments in the cooling pond may be accumulating contaminants from cooling operations or from dust blowing from the coal piles. The distribution of contaminants may reflect the cooling pond's circulation patterns. Some of the contaminants, particularly copper, chromium, and arsenic, may be related to wood preservatives used on the dock. The extent of sediment contamination within the cooling pond is limited to the cooling pond because it is an isolated water body. However, the cooling pond is connected hydraulically to groundwater. Since the surface water within the cooling pond does not have comparable levels of the COPCs, with the exception of manganese and iron, there is little evidence to suggest that contaminants in sediments in the cooling pond could migrate by surface water to groundwater.

Sediment samples also were collected from potential drainage ditches north and south of the cooling pond. Concentrations of barium, beryllium, chromium, copper, manganese, and vanadium above background concentrations or RBCs were found at both locations. The extent of this contamination cannot be determined with available data.

6.3.4 Extent of Surface Water Contamination

Surface water contamination is limited to the CSY cooling pond. The cooling pond is an isolated water body that does not receive or drain water from other water bodies.

However, the cooling pond is connected hydraulically to groundwater; therefore, contaminants may migrate to and from the cooling pond into groundwater. Concentrations of iron in the cooling pond were similar to those found in groundwater. The elevated concentrations of iron and manganese, above MCLs, may have originated from contaminant migration from groundwater. On the other hand, the warm water in the cooling pond, approximately 80°F, would increase the solubility of these and other elements. The origin of the methylene chloride found in the cooling pond is uncertain. It also was detected in two groundwater wells, but there is no clearly defined plume between the wells and the cooling pond.

6.3.5 Extent of Groundwater Contamination

Inorganic contamination in groundwater is limited to antimony, iron, and manganese, which were detected at concentrations exceeding their respective MCLs (see Figure 6-13). Although no apparent pattern exists in the distribution of this contamination, those wells immediately west of the cooling pond have elevated levels of these elements. A contributing factor may be the warmth of the cooling pond's water increasing the solubility of these elements in nearby groundwater. Concentrations of these elements also were found in upgradient and cross-gradient wells. No contaminant distribution pattern may indicate that the contamination reflects local background conditions.

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At this time, the groundwater VOC contamination appears to be limited to the coal pile and the fenced storage yard (see Figure 6-14).

The three wells in the fenced storage yard contained elevated levels of TCE. TCE $(9.7 \mu g/L)$ was detected at a depth of 80 feet BGS. Subsequent samples at 90 and 100 feet BGS did not exhibit detectable contamination. TCE contamination identified at concentrations of $56 \mu g/L$ and $7 \mu g/L$ at monitoring wells 3595-01 and 3595-02 in the fenced storage yard does not appear to follow an identified plume. Samples from MicroWells installed beneath the coal pile contained VOCs (BTEX; cis-1,2-dichloroethene; and tetrachloroethene) at concentrations above RBCs. Most of the VOCs were present in the 30-to-40-feet-BGS range. The presence of chlorinated compounds was no longer detected at approximately 90 feet BGS. BTEX compounds were present at a depth of approximately 90 to 100 feet BGS.

The highest concentrations of VOCs were detected directly beneath the coal pile. The VOCs identified in the fenced storage yard suggest that they could have originated from the fuel application on the coal pile; however, Geoprobe™ locations between the coal pile and

fenced storage yard did not identify a continuing plume connecting the two areas. If fuels and solvents were stored in the UST in the fenced storage yard for later application to the coal pile, localized contamination may be related to the UST if it leaked.

Pesticides were detected in the three wells in the fenced storage yard and the Fort's drinking water wells (3559A, 3559B, 119, and 99), as well as in AP-6522 installed in 1994 (see Figure 6-15). This contamination does not appear to be attributable to CSY operations because dieldrin and heptachlor epoxide were detected only in downgradient wells and not in any at the CSY. Heptachlor was detected in one well within the fenced storage area and in AP-6522. Endrin ketone and 4,4'-DDE were detected in AP-6522, and at no other location.

Fuels were detected in numerous monitoring wells. The highest concentrations of bunker C-range organics, diesel, and TRPH were detected in AP-6142 and/or AP-6143 northwest of the cooling pond. Diesel was detected at AP-6523 in this well. TRPH and/or bunker C-range organics were detected in most of the monitoring wells, including the background wells AP-5508, AP-5734, AP-5735, and AP-6141 and downgradient and crossgradient wells AP-5517, AP-6141, AP-6142, AP-6521, AP-6523, and 99. Although the southern extent of this petroleum-related contamination is not defined, the northern boundary appears to be south of well 119.

Dioxin and furan congeners were detected in upgradient, source area, cross-gradient, and downgradient wells. In several samples, results for a few of the congeners were B-qualified, indicating that the detected concentration was less than 20 times the concentration detected in the corresponding blank. The highest concentrations are in well AP-5734 and AP-6141 upgradient of the CSY. The extent of this contamination cannot be determined with the available data.

Groundwater contamination was characterized on the basis of monitoring wells completed at the water table, deeper aquifer intervals ranging from 60 feet to 181 feet BGS, and water supply wells completed at approximately 180 feet BGS. Groundwater contamination was identified at depth only at MicroWell locations (i.e., PS-1, PS-2, PS-3, and PS-4) within the coal pile area. Downgradient wells completed at the water table and at depth did not indicate contamination. The closest water supply well used for drinking water downgradient of the coal pile is well 119 approximately 1,400 feet northwest. Monitoring wells AP-6144, AP-6143, AP-6142, AP-6519, AP-6520, and AP-6518 are within the general downgradient area between well 119 and the coal pile area.

Table 6-16 lists the analytes exceeding background concentrations or RBCs at the CSY.

6.4 CHEMICAL-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO-BE-CONSIDERED CRITERIA

Chemical-specific ARARs/TBCs for the CSY are presented below. Action-specific ARARs will be presented in the OU-4 feasibility study. Location-specific ARARs were discussed in Section 3.6.

A preliminary list of chemical-specific ARARs and TBCs was developed during preparation of the OU-4 Management Plan. Many of the substances identified initially were not detected in the most recent sampling events, and additional substances that had not been identified previously were detected. Tables 6-17 and 6-18 present an updated list of chemical-specific ARARs and TBCs for groundwater, soil, and sediment.

Because the State of Alaska has been authorized formally to implement the drinking water program, the state MCLs are cited instead of the federal MCLs as ARARs for groundwater (the federal and state MCLs are identical). In addition, the State of Alaska water standards were cited as TBCs. These include values from the water quality standards tables and from the State of Alaska Water Quality Standards Workbook (ADEC 1991b). EPA, Region 3, RBCs are identified as TBCs for groundwater constituents for which there are no primary MCLs. The RBC for groundwater represents either a risk of one person in 1 million developing cancer for carcinogens, or a hazard quotient of one for noncarcinogens.

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No federal or state chemical-specific ARARs exist for soils; therefore, standards contained in state guidance documents are used. However, the State of Alaska Oil and Hazardous Substances Pollution Control regulations (18 AAC 75) require that any person discharging a hazardous substance to land or waters must report it immediately to the State of Alaska. In addition, the discharge must be cleaned up to the department's satisfaction. Eighteen AAC 75 provides the regulatory basis for the cleanup of non-UST-related contamination in soils and must be considered a TBC (ADEC 1991). This guidance states that soils contaminated by hazardous substances, other than crude oil or refined petroleum fuel products, must be cleaned to background levels or levels shown through leaching to not pose risk to potential surface receptors or groundwater. Also included as TBCs are EPA-generated RBCs.

Table 6-1 COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Previous Investigations	Depth
Monitoring V	Vells
AP-5508	18.5
AP-5509	14.0
AP-5510	6
AP-5511	7
AP-5517	24.1
AP-5734	18.9
AP-5735	18.9
AP-5736	25
3595-01	20
3595-02	18
3595-03	18
3559A	100
3559B	100
119	_
101	118
99 (3594)	-
1993	_
AP-6141	29
AP-6142	60
AP-6143	30
AP-6144	30
1994	
AP-6518	24
AP-6519	85
AP-6520	181
AP-6521	31
AP-6522	181
AP-6523	29

Table 6-1 COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Previous Investigations	Depth
AP-6524	75
Borings	
1993	
AP-6158	20
AP-6160	44
AP-6161	20
AP-6162	17.5
AP-6163	19
AP-6164	19
AP-6165	59
AP-6166	19
AP-6167	19
AP-6168	19

CORRELATION OF ASTM D2487 SOIL CLASSIFICATION AND GEOLOGIST'S FIELD CLASSIFICATION COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Location	Sample Number	Depth (ft bgs)	ASTM	Field Class
AP-6158	93CSY016SS	0.25	SM	SM
AP-6159	93CSY018SS	0.25	SM	SM
AP-6162	93CSY019SS	0.25	SM	SP/SM
AP-6161	93CSY028SS	3.0	ML	SM
AP-6161	93CSY09SB	11.0	ML	SM
AP-6142	93CSY025SB	9.0	GP/GM	SP/SM
AP-6142	93CSY026SB	19.0	GM	SP
AP-6163	93CSY036SB	10.0	ML	SM

Key:

ASTM = American Society for Testing and Materials.

ft/bgs = Feet below ground surface.

GP/GM = Poorly graded gravel/silty gravel.

ML = Silt.

SM = Silty sand.

SP = Poorly graded sand.

SP/SM = Poorly graded sand/silty sand.

RISK-BASED^a AND BACKGROUND CONCENTRATIONS FOR ANALYTES DETECTED IN THE COAL STORAGE YARD REMEDIAL INVESTIGATION OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

	Analytes Detecte	Analytes Detected in Surface and Groundwater					
Analyte	Surface Soil (mg/kg)	Subsurface Soil Sediment (mg/kg) (mg/kg)		Risk-Based Concentration (mg/kg) ^b	Analyte	Groundwater (μg/L)	Risk-Based Concentration (µg/L) ^c
Inorganics					Inorganics (Dissolved)		
Aluminum	8,630	4,680	8,200	N/A	Antimony	25U	1.5
Arsenic	14	14	5.1	0.037	Arsenic	20	0.038
Barium ·	115	115	122	550	Barium	341	260
Beryllium	0.43	0.25	0.37	0.015	Calcium	79,800	N/A
Cadmium	1.8	1.8	0.46U	3.9	Chloride	8,300	N/A
Calcium	4,310	2,250	3,740	N/A	Copper	5U	140
Chromium	19	19	15	39	Fluoride	500	220
Cobalt	8.7	4.8	7.5	N/A	Iron	1,700	N/A
Copper	23.4	8.7	20.7	290	Lead	9.9	15
Iron	16,900	9,870	14,900	N/A	Magnesium	23,400	N/A
Lead	26	26	36.8	400	Manganese	780	18
Magnesium	4,730	2,830	4,280	N/A	Nickel	10U	73
Manganese	184	173	164	39	Nitrate as Nitrogen	500	5,800
Mercury	0.08U	0.1U	0.89U	2.3	Nitrite-N	2.5	370
Nickel	17.7	9.4	17.7	160	Orthophosphate	68	N/A
Nitrate as Nitrogen				13,000	Potassium		N/A
Potassium	912	512	947	N/A	Silica	12,700	N/A

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RISK-BASED^a AND BACKGROUND CONCENTRATIONS FOR ANALYTES DETECTED IN THE COAL STORAGE YARD REMEDIAL INVESTIGATION OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

	Analytes Detecte	d in Soils and Sec	liment		Analytes Detected in	Surface and Gro	undwater
Analyte	Surface Soil (mg/kg)	Subsurface Soil (mg/kg)	Sediment (mg/kg)	Risk-Based Concentration (mg/kg) ^b	Analyte	Groundwater (μg/L)	Risk-Based Concentration (µg/L) ^c
Selenium	0.28U	0.32U	0.29U	39	Sodium	6,600	N/A
Silver	0.55U	0.65U	0.58U	39	Sulfate	38,200	N/A
Sodium	347	196	282	N/A	Zinc	5U	1,100
Thallium	0.55	0.65	0.16	0.55	Organics		
Vanadium	35.3	20.3	30	55	1,2,3,4,6,7,8-HpCDD		0.000045
Zinc	48.8	21.6	60.4	2,300	1,2,3,4,6,7,8-HpCDF		0.000045
Organics					1,2,3,6,7,8-HxCDF		0.0000045
1,2,3,4,7,8-HxCDF				0.0000043	1,2,3,7,8,9-HxCDD		0.0000045
1,2,4-Trimethylbenzene				N/A	bis(2-ethylhexyl)phthalate		4.8
1,2-Dichloropropane				0.94	Di-n-butylphthalate		370
1,3,5-Trimethylbenzene				N/A	Dieldrin		0.0042
1,3-Dichloropropane				N/A	4,4'-DDE		0.2
2,3,7,8-TCDD				0.00000043	Endrin ketone		N/A
2,3,7,8-TCDF				0.0000043	Heptachlor		0.0023
2-Butanone				4,700	Heptachlor Epoxide		0.0012
2-Methylnaphthalene				N/A	m & p-Xylene		52
4,4'-DDD				0.27	Methoxychlor		18
4,4'-DDE				0.19	Methylene Chloride		4.1

RISK-BASED^a AND BACKGROUND CONCENTRATIONS FOR ANALYTES DETECTED IN THE COAL STORAGE YARD REMEDIAL INVESTIGATION OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

	Analytes Detecte	d in Soils and Sec		Analytes Detected in	Surface and Gro	undwater	
Analyte	Surface Soil (mg/kg)	Subsurface Soil (mg/kg)	Sediment (mg/kg)	Risk-Based Concentration (mg/kg) ^b	Analyte	Groundwater (μg/L)	Risk-Based Concentration (µg/L) ^c
4,4'-DDT				0.19	o-Xylene		140
Acenaphthene				470	Trichloroethene		N/A
Acenaphthylene				N/A	Trichlorofluoromethane		130
Acetone				780			
Anthracene				2,300			
Aroclor 1260				0.0083			
Benzene				2.2			
Benzo(a)anthracene				0.087			
Benzo(a)pyrene				0.0088			
Benzo(b)fluoranthene				0.087			
Benzo(g,h,i)perylene				N/A			
Benzo(k)fluoranthene				0.88			
bis(2-ethylhexyl)phthalate				4.6			
Chrysene				8.7			
cis-1,2-Dichloroethene				78			
cis-1,3-Dichloropropene				0.35			
Di-n-butylphthalate				780			
Dibenzo(a,h)anthracene				0.0088			

RISK-BASED^a AND BACKGROUND CONCENTRATIONS FOR ANALYTES DETECTED IN THE COAL STORAGE YARD REMEDIAL INVESTIGATION OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

	Analytes Detecte	d in Soils and Sec	diment		Analytes Detected i	n Surface and Gro	oundwater
Analyte	Surface Soil Soil (mg/kg) (mg/kg)		Risk-Based Sediment Concentration (mg/kg) (mg/kg) ^b		Analyte	Groundwater (µg/L)	Risk-Based Concentration (µg/L) ^c
Dibenzofuran				N/A			
Dibromomethane				78			
Dichloroprop				N/A			
Ethylbenzene				780			
Fluoranthene				310			
Fluorene				310			
Indeno(1,2,3-cd)pyrene				0.087			
Isopropylbenzene				310			
m & p-Xylene				16,000			
Methoxychlor				39			
Methylene chloride				8.5			
n-Butylbenzene				N/A			
n-Propylbenzene				N/A			
Naphthalene				N/A			
o-Xylene				16,000			
p-Isopropyltoluene				N/A			
Phenanthrene				N/A			
Pyrene				230			

RISK-BASED^a AND BACKGROUND CONCENTRATIONS FOR ANALYTES DETECTED IN THE COAL STORAGE YARD REMEDIAL INVESTIGATION OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

	Analytes Detecte	d in Soils and Sec	diment		Analytes Detected in	Surface and Gro	oundwater
Analyte	Surface Soil (mg/kg)	Subsurface Soil (mg/kg)	Sediment (mg/kg)	Risk-Based Concentration (mg/kg) ^b	Analyte	Groundwater (μg/L)	Risk-Based Concentration (µg/L) ^c
sec-Butylbenzene				N/A			
Tetrachloroethene				78			
Toluene				1,600			
Trichlorofluoromethane				2,300			

^a United States Environmental Protection Agency, Region 3, Risk-Based Concentration Table, Third Quarter 1994, July 11, 1994, for residential soils and residential ingestion of tap water.

Key:

U =

 μ g/L = Micrograms per liter.

mg/L = Milligrams per liter.

mg/kg = Milligrams per kilogram.

N/A = Not available.

b The risk-based concentrations for soil and sediment correspond to a cancer risk of 1 × 10⁻⁷ or hazard quotient = 0.1. These values were derived assuming a residential soil ingestion scenario.

^C The risk-based concentrations for surface and groundwater to a cancer risk of 1 × 10⁻⁶ or hazard quotient = 0.1. These values were derived assuming a domestic water use scenario.

SUMMARY OF SURFACE AND SUBSURFACE SOIL RESULTS COAL STORAGE YARD OPERABLE UNIT 4

FORT WAINWRIGHT, ALASKA

			Surface Soil						Subsurface Soil			
Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Conc.s	Location of Maximum Conc.	Mean Conc.ª	(new col) Risk- based Conc. ^a	(new col) Back- ground Conc.b	No. of Samples Analyzed/ Detected	Range of Detected Conc.s	Location of Maximum Conc. ^a	Mean Conc. ^b	Risk- based Conc. ^a	Back- ground Conc.b
Inorganics (mg/kg)												
Aluminum	8/8	6,220-44,100	AP-6159	12,300		8,630	29/29	3,650-24,200	AP-6159 6.5'	6,780	_	4,680
Arsenic	8/8	2.4-11.8	AP-6161	7.05	0.037	14 ^c	29/29	1.9-10.9	AP-6159 6.5'	4.77	0.037	14 ^c
Barium	8/8	79-2,630	AP-6159	561	550	115 ^c	29/29	45.7-1,230	AP-6159 6.5'	129	550	115 ^c
Beryllium	8/8	0.32-2.2	AP-6159	0.66	0.015	0.43	29/29	0.19-1.2	AP-6159 6.5'	0.348	0.015	0.25
Cadmium	8/3	0.54-54	AP-6162	18.4	3.9	1.8 ^c	29/6	0.49-1.6	AP-6165 59'	0.82	3.9	1.8 ^c
Calcium	8/8	3,220-68,500	AP-6159	15,200		4,310	29/29	1,660-32,000	AP-6159 6.5'	5,510	_	2,250
Chromium	8/8	10.6-36.3	AP-6159	17.3	39	19 ^c	29/29	7.9-40	AP-6158 20'	14.5	39	19 ^c
Cobalt	8/8	4-13.8	AP-6159	8.29		8.7	29/29	3.1-10.9	AP-6159 6.5'	6.73	_	4.8
Copper	8/8	18.6-57.9	AP-6159	28.9	290	23.4	29/29	6.4-35.9	AP-6159 6.5'	15.7	290	8.7
Iron	8/8	6,170-21,000	AP-6159	14,300	_	16,900	29/29	6,890-21,000	AP-6164 9'	12,600		9,870
Lead	8/8	7.3-22.5	AP-6162	11.5	400	26 ^c	29/29	2.9-13.1	AP-6144 13'	6.75	400	26 ^c
Magnesium	8/8	2,110-8,310	AP-6159	4,470		4,730	29/29	2,100-6,600	AP-6159 6.5'	3,860	_	2,830
Manganese	8/8	134-572	AP-6159	267	39	184	29/29	80.7-413	AP-6159 6.5'	205	39	173
Mercury	8/1	0.12	AP-6159		2.3	0.08U	29/0				2.3	0.1U

Key at end of table.

SUMMARY OF SURFACE AND SUBSURFACE SOIL RESULTS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

			Surface Soil				Subsurface Soil						
Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Conc.s	Location of Maximum Conc.	Mean Conc.ª	(new col) Risk- based Conc. ^a	(new col) Back- ground Conc. ^b	No. of Samples Analyzed/ Detected	Range of Detected Conc.s	Location of Maximum Conc. ^a	Mean Conc. ^b	Risk- based Conc. ^a	Back- ground Conc.b	
Nickel	8/8	9.2-30.8	AP-6159	18.4	160	17.7	29/29	9.4-26.4	AP-6159 6.5'	15.2	160	9.4	
Potassium	8/8	365-2,740	AP-6159	912	_	912	29/29	382-1,300	AP-6159 6.5'	636		512	
Selenium	8/1	52	AP-6159	<u> </u>	39	0.28U	29/1	0.42	AP-6163 19'	_	39	0.32U	
Silver	8/2	0.59-0.91	AP-6161	0.75	39	0.55U	29/6	0.61-0.96	AP-6165 59'	0.723	39	0.65U	
Sodium	8/8	163-596	AP-6159	322	<u> </u>	347	29/29	147-483	AP-6144 13'	270		196	
Vanadium	8/8	25.8-112	AP-6159	41.4	55	35.3	29/29	13.6-73.3	AP-6159 6.5'	27.9	55	20.3	
Zinc	8/8	12.8-48.5	AP-6141	33.1	2,300	48.8	29/29	17.9-51.6	AP-6164 9'	29.5	2,300	21.6	
Organics (mg/kg)													
4,4'-DDT	8/8	0.0045-0.13	AP-6158	0.038	0.19	NA	29/6	0.002-0.23	AP-6166 14'	0.0647	0.19	NA	
4,4'-DDE	8/1	0.006	AP-6158	_	0.19	NA	29/2	0.003-0.012	AP-6159 6.5'	0.0075	0.19	NA	
4,4'-DDD	8/8	0.0014-0.053	AP-6158	0.014	0.27	NA	29/3	0.0069-0.089	AP-6166 14'	0.0433	0.27	NA	
Di-n-butylphthalate	8/8	0.18-0.85	A-6160	0.506	780	NA	29/28	0.23-2.3	AP-6165 47'	0.8	780	NA	
Methylene Chloride	8/1	0.006	AP-6161	_	8.5	NA	30/9	0.002-0.019	AP-6164 9'	0.0068	8.5	NA	
Toluene	8/3	0.002-0.13	AP-6158	0.047	1,600	NA	30/10	0.002-180	AP-6160 32'	19	1,600	NA	
Trichlorofluoromethane	8/3	0.064-0.51	AP-6158	0.265	2,300	NA	30/1	0.007	AP-6168 19'	_	2,300	NA	

SUMMARY OF SURFACE AND SUBSURFACE SOIL RESULTS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

			Surface Soil	l			Subsurface Soil					
Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Conc.s	Location of Maximum Conc.	Mean Conc.ª	(new col) Risk- based Conc. ^a	(new col) Back- ground Conc.b	No. of Samples Analyzed/ Detected	Range of Detected Conc.s	Location of Maximum Conc. ^a	Mean Conc. ^b	Risk- based Conc. ^a	Back- ground Conc. ^b
1,2,4-trimethylbenzene	8/0	_	_	-	_	NA	30/5	0.007-0.22	AP-6168 97'	0.0708		NA
1,2-dichloropropane	8/0	_		_	0.94	NA	30/1	0.006	AP-6160 27.5'	_	0.94	NA
1,3,5-trimethylbenzene	8/0					NA	30/4	0.023-9	AP-6160 27.5'	2.33	_	NA
1,3-dichloropropane	8/0	_	_	. –	_	NA	30/1	0.006	AP-6160 27.5'	_	_	NA
Aroclor 1260	8/0	_	_	_	0.0083	NA	29/2	0.0052-0.025	AP-6167 19'	0.0151	0.0083	NA
Benzene	8/0	_	_	_	2.2	NA	30/6	0.006-14	AP-6160 32'	2.47	2.2	NA
bis(2-Ethylhexyl)phthalate	8/0	_	_	J	4.6	NA	29/8	0.028-1.4	AP-6160 32'	0.301	4.6	NA
cis-1,3-Dichloropropene	8/0	_	_	_	0.35	NA	30/1	0.006	AP-6160 27.5'	_	0.35	NA
cis-1,2-Dichloroethene	8/0	_	_	_	78	NA	30/3	0.006-0.026	AP-6167 19'	0.0127	78	NA
Dibromomethane	8/0	_	_		78	NA	30/1	0.006	AP-6160 27.5'	_	78	NA
Dichloroprop	8/0	_		j	_	NA	29/2	0.035-0.04	AP-6161 11'	0.0375	_	NA
Ethylbenzene	8/0		_	_	780	NA	30/7	0.006-86	AP-6160 32'	13.3	780	NA
Isopropylbenzene	8/0	_	_		310	NA	30/4	0.019-0.77	AP-6160 32'	0.365	310	NA
m&p-Xylene	8/0		_	_	16,000	NA	30/11	0.003-300	AP-6160 32'	30.5	16,000	NA
n-Butylbenzene	8/0	_	_			NA	30/4	0.011-0.28	AP-6160 32'	0.121		NA

Key at end of table.

19:JZ5901_S050-T63-06/22-05

SUMMARY OF SURFACE AND SUBSURFACE SOIL RESULTS COAL STORAGE YARD OPERABLE UNIT 4

FORT WAINWRIGHT, ALASKA

			Surface Soil						Subsurface Soil		·····	
Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Conc.s	Location of Maximum Conc.	Mean Conc.ª	(new col) Risk- based Conc. ^a	(new col) Back- ground Conc. ^b	No. of Samples Analyzed/ Detected	Range of Detected Conc.s	Location of Maximum Conc. ^a	Mean Conc. ^b	Risk- based Conc. ^a	Back- ground Conc. ^b
n-Propylbenzene	8/0	_	_	_	_	NA	30/3	0.2-0.99	AP-6160 32'	0.643	_	NA
Naphthalene	8/0	_	_	_	_	NA	29/6	0.004-0.34	AP-6160 27.5'	0.136	_	NA
o-Xylene	8/0	_	_	_	16,000	NA	30/8	0.009-110	AP-6160 32'	15.7	16,000	NA
p-Isopropyltoluene	8/0	-	_	-	_	NA	30/5	0.021-0.92	AP-6160 27.5'	0.243	_	NA
sec-Butylbenzene	8/0	-		_	_	NA	30/4	0.018-0.38	AP-6160 32'	0.206	-	NA
Tetrachloroethene	8/0	I	_	_	78	NA	30/3	0.006-11	AP-6160 32'	3.67	78	NA
2-Methylnaphthalene	8/0	-	_		_	NA	30/1	4.0	AP-6160 32'	_	-	NA
1,1,1-Trichloroethane	8/0		_	_		NA	30/1	9.0	AP-6160.32'	_	-	NA
Trichloroethene	8/0	1	_	_	_	NA	30/1	0.033	AP-6167 19'	_	_	NA
Fuels (mg/kg)												
TRPH	8/7	25.7-4,760	AP-6160	838	_	NA	29/17	9.1-60,000	AP-6160 32'	3,800	_	NA
Bunker Oil (No. 6 Diesel)	8/5	53-3,400	AP-6160	1,122	_	NA	29/9	34-35,000	AP-6160 15.5'	2,300	_	NA
Diesel	8/2	25-270	AP-6160	147.7	_	NA	29/7	5.1-5,900	AP-6160 15.5'	952	1	NA
Kerosene	8/0	_	_		_	NA	29/1	32	AP-6165, 19'			NA
Gasoline-Range Organics	2/2	1.2-1.4	AP-6158	1.3	_	NA	2/0				-	NA

Key at end of table.

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SUMMARY OF SURFACE AND SUBSURFACE SOIL RESULTS COAL STORAGE YARD OPERABLE UNIT 4

FORT WAINWRIGHT, ALASKA

			Surface Soil	l					Subsurface Soi	l		` <u>-</u> i
Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Conc.s	Location of Maximum Conc.	Mean Conc.ª	(new col) Risk- based Conc. ^a	(new col) Back- ground Conc.b	No. of Samples Analyzed/ Detected	Range of Detected Conc.s	Location of Maximum Conc. ^a	Mean Conc.b	Risk- based Conc. ^a	Back- ground Conc. ^b
Diesel-Range Organics	2/2	1,000-1,500	AP-6158	1,250								
Dioxin/Furans (pg/g)												
1,2,3,4,6,7,8,9-OCDD	8/8	7.11-912	AP-6141	252.9	410	NA	20/16	1.94-38.8	AP-6142 9'	12.1	410	NA
1,2,3,4,6,7,8,9-OCDF	8/7	0.79-45.4	AP-6141	13.7	410	NA	20/12	0.16-5.8	AP-6160 32'	1.2	410	NA
1,2,3,4,6,7,8-HpCDD	8/7	1.3-86.6	AP-6162	34.5	41	NA	20/15	0.36-6.32	AP-6160 32'	1.8	41	NA
1,2,3,4,6,7,8-HpCDF	8/8	0.49-23.4	AP-6141	5.8	41	NA	20/12	0.088-1.06	AP-6160 32'	0.4	41	NA
1,2,3,4,7,8,9-HpCDF	8/3	0.25-1.26	AP-6141	0.797	41	NA	20/2	0.02-0.06	AP-6142 19'	0.04	41	NA
1,2,3,4,7,8-HxCDD	8/4	0.16-1.61	AP-6141	0.958	4.1	NA	20/2	0.07-0.535	AP-6160 32'	0.3	4.1	NA
1,2,3,4,7,8-HxCDF	8/6	0.059-1.31	AP-6162	0.602	4.1	NA	20/13	0.024-0.82	AP-6160 32'	0.118	4.1	NA
1,2,3,6,7,8-HxCDD	8/6	0.4-4.39	AP-6162	2.2	4.1	NA	20/2	0.15-1.27	AP-6160 32'	0.71	4.1	NA
1,2,3,6,7,8-HxCDF	8/5	0.12-1.04	AP-6162	0.558	4.1	NA	20/4	0.039-0.148	AP-6160 32'	0.07	4.1	NA
1,2,3,7,8,9-HxCDD	8/6	0.14-3.74	AP-6141	1.9	4.1	NA	20/3	0.08-0.7	AP-6160 32'	0.303	4.1	NA
1,2,3,7,8-PeCDD	8/2	0.12-0.57	AP-6158	0.345	0.82	NA	20/1	0.268	AP-6160 32'	_	0.82	NA
1,2,3,7,8-PeCDF	8/1	0.216	AP-6141		8.2	NA	20/1	0.18	AP-6160 32'		8.2	NA
2,3,4,6,7,8-HxCDF	8/5	0.33-1.89	AP-6162	1.2	4.1	NA	20/13	0.13-0.32	AP-6159 6.5'	0.184	4.1	NA

Key at end of table.

19:JZ5901_S050-T63-06-20-05

SUMMARY OF SURFACE AND SUBSURFACE SOIL RESULTS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

			Surface Soil	l					Subsurface Soil			
Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Conc.s	Location of Maximum Conc.	Mean Conc.ª	(new col) Risk- based Conc. ^a	(new col) Back- ground Conc. ^b	No. of Samples Analyzed/ Detected	Range of Detected Conc.s	Location of Maximum Conc. ^a	Mean Conc. ^b	Risk- based Conc. ^a	Back- ground Conc. ^b
2,3,7,8-TCDD	8/1	0.0557	AP-6161	_	0.41	NA	20/3	0.047-0.0929	AP-6163 19'	0.069	0.41	NA
2,3,7,8-TCDF	8/1	0.26	AP-6158	_	4.1	NA	20/0	_	_	_	4.1	NA
Total HpCDD	8/7	2.38-178	AP-6162	67	_	NA	20/19	0.39-15.7	AP-6160 32'	2.9	_	NA
Total HpCDF	8/8	0.55-74.3	AP-6141	17.3	_	NA	20/16	0.13-2.9	AP-6142 19'	0.725	_	NA
Total HxCDD	8/8	0.138-29.9	AP-6162	11.8	_	NA	20/19	0.125-11.6	AP-6160 32'	2.0	-	NA
Total HxCDF	8/8	0.47-33.4	AP-6141	12.8	_	NA	20/19	0.015-2.48	AP-6160 32'	0.558	_	NA
Total PeCDD	8/6	1.51-10.4	AP-6162	5.8		NA	20/14	0.196-2.24	AP-6161 11'	1.0	-	NA
Total PeCDF	8/8	0.31-57	AP-6162	23.8	_	NA	20/5	0.158-3.33	AP-6163 19'	1.3	-	NA
Total TCDD	8/8	0.21-25.8	AP-6158	9.5	_	NA	20/17	0.12-4.9	AP-6161 11'	1.4	_	NA
Total TCDF	8/8	0.33-12.4	AP-6162	5		NA	20/14	0.04-1.36	AP-6161 11'	0.326	_	NA
Other (mg/kg)												
TOC (%)	8/8	0.544-19.4	AP-6158	6.32	_	NA	29/29	0.028-6.0	AP-6166 19'	6.5	-	NA
Nitrate as Nitrogen	8/5	2.7-110	AP-6158	25.5	13,000	NA	4/1	2.4	AP-6161 11'		13,000	NA
Total Phosphorus	8/5	196-603	AP-6161	404	_	NA	9/4	56.3-484	AP-6161 11'	288	_	NA

NOTE: Highlighted areas indicate the comparison criteria used to determine whether analyte was a chemical of potential concern.

Key at end of table.

19:JZ5901_S050-T63-06/22/95

6-45

NA = Not applicable. pg/g = Picograms per gram. TOC = Total organic carbon.

U =

TRPH = Total recoverable petroleum hydrocarbon.

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a United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 1 × 10<sup>-7</sup>. Hazard quotient = 0.1. b

b Surface and subsurface soil background data from sample location AP-6141, unless otherwise noted.

c Surface and subsurface soil background data provided by the Corps.

Key:

-- = Not analyzed.

Conc. = Concentration.

mg/kg = Milligrams per kilogram.
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FSVOC RESULTS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Matrix	Analyte	Number of Samples with Detections	Range of Detected Conc.	Mean Conc.	Kisk-Based Conc. ^a
Surface Soil (μg/kg)	o-Xylene	1	6.8		16,000,000
	PCE	1	18.0		78,000
Subsurface Soil (µg/kg)	Benzene	11	14.4-22,280	3,147	2,200
	Toluene	9	5.7-16,400	1,957	1,600,000
	Ethylbenzene	11	10.4-18,670	1,839	780,000
	Chlorobenzen e	3	19.9-42.9	31.3	160,000
	m & p- Xylenes	7	5.9-190	95.5	16,000,000
	o-Xylene	8	12.4-396	133	16,000,000
	1,1-DCE	9	15.3-279	69.5	110
	TCE	11	18.1-185,700	17,815	_
	1,1,1-TCA	4	560-38,090	10,415	_
	1,1,2-TCA	1	54		1,100
	PCE	11	5.3-1,160	385	78,000
Groundwater (μg/L)	Benzene	9	6.8-870	184	0.36
	Toluene	9	6.1-2,550	660	75
	Ethylbenzene	8	5.5-550	120	130
	m&p-Xylenes	8	9.1-790	255	140
	o-Xylene	9	6.0-1,020	251	140
	1,1-DCA	5	13.1-196	87.4	81
	TCE	9	5.8-820	113	_
	1,1,1-TCA	3	46.5-653	300	
	1,1,2-TCA	1	25.8		0.19
	PCE	7	6.0-410	80.0	6.1
	1,1,2,2-PCA	3	5.9-653	31.2	0.052

^a United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk for soils = 1×10^{-7} . Cancer risk for groundwater = 1×10^{-6} . Hazard quotient = 0.1.

Key:

FSVOC = Field screening volatile organic compounds.

 μ g/L = Micrograms per liter.

 μ g/kg = Micrograms per killogram.

SUMMARY OF SEDIMENT RESULTS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT ALASKA

			Sedin	nents		
Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration ^a	Risk-Based Concentration ^a	Background Concentration ^b
Inorganics (mg/kg)						
Aluminum	11/11	4,330-26,800	SD-9	10,600	_	8,200
Arsenic	11/10	1.4-31.1	SD-9	8.95	0.037	5.1
Barium	11/11	74.3-930	SD-9	394	550	122
Beryllium	11/11	0.2-1.8	SD-9	0.594	0.015	0.37
Cadmium	11/2	0.93-1.8	SD-5	1.37	3.9	0.46U
Calcium	11/11	3,740-90,300	SD-5	22,400	_	3,740
Chromium	11/11	7.8-48.9	SD-9	19.2	39	15
Cobalt	11/11	4.4-30.2	SD-9	10.7		7.5
Copper	11/11	20.7-26,700	SD-9	2,780	290	20.7
Iron	11/11	8,780-127,000	SD-9	32,700	-	14,900
Lead	11/11	6.7-99	SD-5	30.5	400	36.8
Magnesium	11/11	2,970-22,800	SD-5	7,050	_	4,280
Manganese	11/11	148-6,570	SD-5	1,140	39	164
Mercury	11/5	0.14-4.2	SD-5	1.18	2.3	0.89U
Nickel	11/11	11.9-53.4	SD-9	24.8	160	17.7

SUMMARY OF SEDIMENT RESULTS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT ALASKA

			Sedin	nents		
Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration ^a	Risk-Based Concentration ^a	Background Concentration ^b
Potassium	11/10	388-2,020	SD-9	923	_	947
Selenium	11/3	0.3-0.34	SD-2	0.32	39	0.29U
Sodium	11/11	159-871	SD-9	384	_	282
Thallium	11/4	0.12-0.16	SD-10	0.143	0.55	0.16
Vanadium	11/11	16.5-115	SD-9	41.6	55	30
Zinc	11/11	27.7-1,780	SD-5	266	2,300	60.4
Organics (mg/kg)						
2-Butanone	11/3	0.011-0.034	SD-7	0.020	4,700	NA
2-Methylnaphthalene	11/1	0.55	SD-5	_	_	NA
4,4'-DDD	11/5	0.0023-0.019	SD-7	0.0086	0.27	NA
4,4'-DDE	11/3	0.0022-0.0066	SD-7	0.0038	0.19	NA
4,4'-DDT	11/7	0.0022-0.02	SD-1	0.0077	0.19	NA
Acenaphthene	11/2	0.98-1.8	SD-9	1.39	470	NA
Acenaphthylene	11/1	0.19	SD-5	_	_	NA
Acetone	11/11	0.008-1.5	SD-9	0.163	780	NA
Anthracene	11/2	0.55-2.2	SD-9	1.38	2,300	NA
Benzo(a)anthracene	11/1	2.4	SD-5		0.087	NA

SUMMARY OF SEDIMENT RESULTS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT ALASKA

		Sediments								
Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration ^a	Risk-Based Concentration ^a	Background Concentration ^b				
Benzo(a)pyrene	11/2	0.54-1.2	SD-5	0.87	0.0088	NA				
Benzo(b)fluoranthene	11/2	0.79-2.1	SD-5	1.44	0.087	NA				
Benzo(g,h,i)perylene	11/1	0.22	SD-5		_	NA				
Benzo(k)fluoranthene	11/2	0.86-1.2	SD-5	1.03	0.88	NA				
bis(2-ethylhexyl)phthalate	11/1	0.53	SD-5	_	4.6	NA				
Chrysene	11/2	1.4-2.9	SD-5	2.15	8.7	NA				
Di-n-butylphthalate	11/11	0.35-9.3	SD-9	1.70	780	NA				
Dibenzo(a,h)anthracene	11/1	0.19	SD-5	_	0.0088	NA				
Dibenzofuran	11/2	2-2.5	SD-9	2.25		NA				
Fluoranthene	11/2	3.2-7.5	SD-5	5.35	310	NA				
Fluorene	11/2	1.9-2	SD-5	1.95	310	NA				
Indeno(1,2,3-cd)pyrene	11/1	0.26	SD-5	_	0.087	NA				
Methoxychlor	11/1	0.0023	SD-8	_	39	NA				
Methylene Chloride	11/6	0.008-0.01	SD-3/SD-10	0.0088	8.5	NA				
Naphthalene	11/2	0.007-0.56	SD-5	0.284	-	NA				
Phenanthrene	11/2	1.7-5.2	SD-5	3.45	_	NA				
Pyrene	11/2	2.7-7.4	SD-5	5.05	230	NA				

SUMMARY OF SEDIMENT RESULTS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT ALASKA

		Sediments									
Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration ^a	Risk-Based Concentration ^a	Background Concentration ^b					
Fuels (mg/kg)											
ТПРН	11/4	39.2-627	SD-5	284		· NA					
Bunker Oil	7/4	43-640	SD-5	217		NA					
Diesel-Range Organics	2/2	6.5-8.9	SD-1	7.7		NA					
Dioxin/Furans (pg/g)											
1,2,3,4,6,7,8,9-OCDD	1/1	33.2	SD-7	_	410	NA					
1,2,3,4,6,7,8,9-OCDF	1/1	1.09	SD-7	_	410	NA					
1,2,3,4,6,7,8-HpCDD	1/1	3.98	SD-7		41	NA					
1,2,3,4,6,7,8-HpCDF	1/1	0.66	SD-7	_	41	NA					
1,2,3,6,7,8-HxCDD	1/1	0.3	SD-7	_	4.1	NA					
1,2,3,7,8,9-HxCDD	1/1	0.46	SD-7	_	4:1	NA					
1,2,3,7,8-PeCDF	1/1	0.16	SD-7		8.2	NA					
2,3,4,6,7,8-HxCDF	1/1	0.21	SD-2		4.1	NA					
2,3,4,7,8-PeCDF	1/1	0.27	SD-2		0.82	NA					
2,3,7,8-TCDD	1/1	0.18	SD-2		0.41	NA					
2,3,7,8-TCDF	1/1	0.2	SD-7		4.1	NA					

SUMMARY OF SEDIMENT RESULTS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT ALASKA

		Sediments									
Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration ^a	Risk-Based Concentration ^a	Background Concentration ^b					
Other											
TOC (%)	11/7	0.516-4.20	SD-5	1.54	_	NA					

NOTE: Highlighted areas indicate the comparison criteria used to determine whether analyte was a chemical of potential concern.

b Sediment background data from sample location SD-10.

Key:

- = Not analyzed.

mg/kg = Milligrams per kilogram.

NA = Not applicable.

pg/g = Picograms per gram.

TOC = Total organic carbon.

TRPH = Total recoverable petroleum hydrocarbon.

U =

^a United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 1 × 10⁻⁷. Hazard quotient = 0.1.

SUMMARY OF SURFACE WATER RESULTS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration ^a	Qua	Water ality a ^b /MCL	Risk-based Concentration ^h
Inorganics							
Total Metals (mg/L)							
Arsenic	2/1	0.033	SD-5	_	0.05	0.05	0.000038
Barium	. 2/2	0.14-0.14	SD-5/SD-9	0.14	1	2	0.26
Copper	2/1	0.01	SD-9	_	0.012 ^c	1 ^f	0.14
Dissolved Metals (mg/L)							
Barium	2/2	0.15-0.19	SD-9	0.17	1 ^d	2	0.26
Calcium	2/2	42.2-43.1	SD-9	42.7	<u> </u>	_	
Iron	2/1	0.69	SD-9	_	id	0.3 ^f	_
Magnesium	2/2	10.8-10.9	SD-9	10.85		_	_
Manganese	2/2	0.058-0.061	SD-9	0.06		0.05 ^f	0.018
Potassium	2/2	2.7-2.8	SD-9	2.75		_	
Sodium	2/2	6-6.3	SD-9	6.15		250 ^f	
Zinc	2/1	0.2	SD-9	_	0.047 ^e	5 ^f	1.1
Organics (µg/L)							
Methylene Chloride	2/1	11	SD-5	_		5g	4.1
Other (mg/L)							
Alkalinity	2/2	133	SD-5/SD-9	_		_	_

SUMMARY OF SURFACE WATER RESULTS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration ^a	Alaska Water Quality Criteria ^b /MCL	Risk-based Concentration ^h
Chloride	2/2	2.4-2.6	SD-5	2.5	- 250f	_
Sulfate	2/2	17.1-17.2	SD-5	17.15	- 250f	_
Silica	2/2	14-14.5	SD-5	14.25	_	
Total Dissolved Solids	2/2	155-196	SD-9	176	- 500 ^f	_

NOTE: Shaded areas indicate the comparison criteria used to determine whether analyte was a chemical of potential concern.

Key:

MCLs = Maximum contaminant levels.

 $\mu g/L$ = Micrograms per liter.

mg/L = Milligrams per liter.

a Rounded mean of detected concentrations.

b 18 AAC 70 (surface water criteria)/18 AAC 80.070 (MCLs).

^C Criteria for dissolved metal used.

d Criteria for total metal used.

e Twenty-four-hour average criteria for total metal used.

f Secondary MCL.

g MCL.

h United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 1 × 10⁻⁶. Hazard quotient = 0.1.

SUMMARY OF 1993 GROUNDWATER RESULTS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration ^a	Qu	a Water ality ia/MCL	Risk-based Concentration ^a	Background Concentration ^b
Total Metals (μg/L)								
Arsenic	20/17	3-59	AP-5509	13.5	50	50	0.038	72 ^c
Barium	20/20	96-500	AP-5517	210	1,000	2,000	260	988 ^c
Calcium	20/15	42,100-211,000	3595-02	74,300			_	71,300 ^d
Copper	20/13	6-110	AP-5510	27.3	12	1,300	140	68
Iron	30/3	10,900-48,400	3595-03	26,100	1,000	300(s)	_	
Lead	20/12	1.6-20	AP-6141	7.1	3.2	15	15	66 ^c
Magnesium	3/3	30,700-49,200	3595-02	41,300	~~~			-
Manganese	3/3	1,100-2,000	3595-01	1,670	_	50(s)	18	
Nickel	20/12	11-38	AP-6141	21.8	96	100	73	38
Sodium	3/3	6,100-8,600	3595-03	7,200	_	_	_	_
Zinc	20/18	7-120	AP-5509-3559A	42.1	47	5,000(s)	1,100	97
Dissolved Metals (μg/L)								
Arsenic	20/10	4-12	AP-5735	6.4	50	50	0.038	20 ^c
Antimony	20/5	26-37	AP-5508	30.2	1,600	6	1.5	25U
Barium	20/20	80-300	AP-5737	164	1,000	2,000	260	341 ^c
Copper	20/1	6	3559A	_	12	1,300	140	5U

SUMMARY OF 1993 GROUNDWATER RESULTS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration ^a	Qu	a Water ality ia/MCL	Risk-based Concentration ^a	Background Concentration ^b
Iron	17/13	75-15,900	AP-5735	3,050	1,000	300(s)	_	1,700
Lead	20/2	4-10	3595-02	7	3.2	15	15	9.9 ^c
Magnesium	17/17	9,900-44,800	AP-5517	16,000	_	_		23,400
Manganese	17/17	60-920	AP-5511	427	_	50(s)	18	780
Nickel	20/4	16-20	3595-02	17.5	96	100	73	10 U
Sodium	17/17	4,200-29,600	AP-5517	7,860	_	_		6,600
Zinc	17/3	18-22	3595-03	19.3	47	5,000	1,100	5U
Organics (µg/L)								
bis(2-Ethylhexyl)phthalate	20/4	2-110	AP-6142	32.5	_	6	4.8	. NA
di-n-Butylphthalate	20/19	1-13	AP-5511	6.99			370	NA
Dieldrin	20/2	0.01-0.021	119	0.016	_		0.0042	NA
Heptachlor	20/1	0.08	3595-02	_	0.0038	0.4	0.0023	NA
Heptachlor epoxide	20/2	0.01-0.02	119	0.015	_	0.2	0.0012	. NA
m&p-Xylene	20/3	2.0	3595/01/2/03	_	_	_	52	NA
Methoxychlor	20/3	0.044-0.16	119	0.09	0.03	40	18	NA
Methylene chloride	20/2	4-6	3595-01	5	_	5	4.1	NA
o-Xylene	20/3	1.0	3595-01/02/03	1.0	_	_	140	NA .

SUMMARY OF 1993 GROUNDWATER RESULTS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Concentrations	Location of Maximum Concentration	Mean Concentration ^a	Alaska Water Quality Criteria/MCL		Risk-based Concentration ^a	Background Concentration ^b	
Trichloroethene	20/2	7-56	3595-01	31.5	5	5		NA	
Trichlorofluoromethane	20/1	29	3595-03	_	11,000	_	2,300	NA	
Fuels (mg/L)									
TRPH	20/12	0.025-2.0	AP-6143	0.651	_			NA	
Diesel No. 2	20/1	0.310	AP-6142	_	_	_		NA	
Bunker Oil (No. 6 Diesel)	20/9	0.39-1.1	AP-6142	0.561		_	_	NA	
Other (mg/L)									
Alkalinity (C-aCO ₃)	20/20	122-590	3595-02	239.35	_	_		NA	
Chloride	20/20	1.8-102	AP-5517	9.11	_	250(s)		8.3	
Fluoride	20/5	0.13-0.26	3559A/B	0.224	2.4	4	_	0.5	
Orthophosphate	20/11	0.052-0.26	AP-5509	0.143	_			0.068	
Silica	20/20	8.2-20.9	AP-6142	15.0		_	_	12.7	
Sulfate	20/20	9.6-152	3595-02	38.4	_	250(s)	_	. NA	
Total organic compounds	20/20	7.1-145	3595-02	47.2	_	_	_	NA	
Total dissolved solids	20/20	68-1780	AP-5509	355	_	_	_	NA	
Biochemical oxygen demand	20/11	1.3-654	AP-5510	74.6	_	_	_	NA	
Nitrate-Nitrate	20/10	0.027-5.3	AP-5517	0.642	10	10	0.37	0.064	

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SUMMARY OF 1993 GROUNDWATER RESULTS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Analyte and Concentration Units			Maximum Mean		Alaska Water Quality Criteria/MCL		Risk-based Concentration ^a	Background Concentration ^b
Dioxin/Furans (pg/L)								
1,2,3,4,6,7,8,9-OCDD	20/3	48.6-77.7	3595-03	59.3	_	30,000	430	NA
1,2,3,4,6,7,8,9-OCDF	20/1	5.46	3595-01		_	30,000	430	NA
1,2,3,4,6,7,8-HpCDD	20/3	10.7-18.3	3595-03	13.8		3,000	43	NA
1,2,3,4,6,7,8-HpCDF	20/2	2.82-4.28	3595-03	3.6	_	3,000	43	NA
1,2,3,4,7,8-HxCDF	20/1	2.43	3595-03	_	_	300	4.3	NA
1,2,3,6,7,8-HxCDF	20/3	0.943-1.45	3595-03	1.2	_	300	4.3	NA
1,2,3,7,8,9-HxCDD	20/1	1.34	3595-02	_	_	300	4.3	NA
1,2,3,7,8,9-HxCDF	20/1	0.971	3595-02	_		300	4.3	NA
1,2,3,7,8-PeCDD	20/1	1.95	3595-02			60	0.86	NA
2,3,4,6,7,8-HxCDF	20/2	3.26-3.42	3595-03	3.3	_	300	4.3	NA
Total HpCDD	20/3	18.3-24.9	3595-02	21.3	_	_		NA
Total HpCDF	20/2	3.14-4.75	3595-03	3.9	_	_	_	, NA
Total HxCDD	20/2	2.53-9.4	3595-02	5.9	_	_	_	NA
Total HxCDF	20/2	0.997-19.9	3595-02	10.6	_	_	_	NA
Total PeCDD	20/3	1.95-1.95	3595-02	1.95				NA
Total PeCDF	20/1	4.01-55.4	3595-02	29.7	_	_	-	NA

SUMMARY OF 1993 GROUNDWATER RESULTS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Analyte and Concentration Units	No. of Samples Analyzed/ Range of Detected Detected Concentrations		Location of Maximum Concentration	Mean Concentration ^a	Alaska Water Quality Criteria/MCL		Risk-based Concentration ^a	Background Concentration ^b
Total TCDF	20/2	0.674-19.3	3595.02	9.9	_	-		NA

NOTE: Highlighted areas indicate the comparison criteria used to determine whether analyte was a chemical of potential concern.

Key:

- = Not analyzed.

BOD = Biochemical oxygen demand.

EPA = United States Environmental Protection Agency.

Fuel ID = Fuel identification.

J = Estimated concentration.

 $\mu g/L$ = Micrograms per liter.

mg/L = Milligrams per liter.

NA = Not applicable.

pg/L = Picogram per liter.

TOC = Total organic compounds.

TRPH = Total recoverable petroleum hydrocarbons.

U =

VOC = Volatile organic compounds.

a United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 1 × 10⁻⁶. Hazard quotient = 0.1.

b Background data from sample locations AP-5734 and AP-6141, unless otherwise noted.

^C Background data provided by the Corps.

d Background data from sample location AP-5734 only.

VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER COAL STORAGE YARD

(μg/L)
OPERABLE UNIT 4
FORT WAINWRIGHT, ALASKA
JULY 1994

Compound	AP-6141	AP-5734	AP-5735	AP-5508	AP-5509	Risk-based Concentrationa
Chloroform	10 B	8 B	<5	9 B	<5	0.15
Methylene chloride	< 5	<5	3 JB	<5	3 ЈВ	4.1
Toluene	<5	<5	1 J	<5	<5	75
Compound	3595-01	3595-02	3595-03	AP-5517	AP-6144	Risk-based Concentrationa
Chloroform	7 B	<5	<5	9 B	8 B	0.15
Trichlorofluoromethane	<5	<5	140	<5	<5	130
cis-1,2 dichloroethylene	<5	<5	2 Ј	<5	<5	6.1
Trichloroethene	11	9	<5	<5	<5	5 ^b
Methylene chloride	<5	2 ЛВ	<5	<5	<5	4.1
Benzene	<5	<5	3 ј	<5	<5	0.36

NOTE: Highlighted areas indicate the comparison criteria used to determine whether analyte was a chemical of potential concern.

Key:

B = Analyte was detected in blank analyses.

J = Estimated concentration.

 μ g/L = Micrograms per liter.

United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 1 × 10⁻⁶. Hazard quotient = 0.1.
 MCL

c Value for halomethanes.

· •<5.

Table 6-10

PETROLEUM HYDROCARBONS RESULTS COAL STORAGE YARD

 $(\mu g/L)$

OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA JULY 1994

Sample Number	Fuel ID Modified 8015	Diesel-range Organics	ТПРН
3595-03	ND	320	ND
AP-6523	140 (Diesel)	130	250
AP-6521	ND	<100	250

Key:

Fuel ID = Fuel identification.

 $\mu g/L$ = Micrograms per liter.

ND = Not detected.

TRPH = Total recoverable petroleum hydrocarbons.

PESTICIDES RESULTS FOR NEW WELLS COAL STORAGE YARD

(μg/L)
OPERABLE UNIT 4
FORT WAINWRIGHT, ALASKA
JULY 1994

Sample Number	4,4'-DDE	Heptachlor	Dieldrin	Endrin Ketone	
AP-6522	0.09	0.04	0.03	0.14	
Risk-based Concentration ^a	0.2	0.0023	0.0042	-	

NOTE: Highlighted areas indicate the comparison criteria used to determine whether analyte was a chemical of potential concern.

Key:

 $\mu g/L$ = Micrograms per liter.

^a United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 1 × 10⁻⁶. Hazard quotient = 0.1.

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Table 6-12

SEMIVOLATILE ORGANICS RESULTS FOR NEW WELLS COAL STORAGE YARD

(μg/L)
OPERABLE UNIT 4
FORT WAINWRIGHT, ALASKA
JULY 1994

Sample Number	Di-n-butylphth	alate	bis(2-ethylhexyl)phthalate			
AP-6518	2	JB	2	J		
AP-6519	3	JB	2	J		
AP-6520	4	JB	<10			
AP-6521	5	JВ	13			
AP-6522	2	JB	<10			
AP-6523	2	JB	<10			
AP-6524 (duplicate)	5	JВ	<10			
Risk-based Concentration ^a	370		4.8			

NOTE: Highlighted areas indicate the comparison criteria used to determine whether analyte was a chemical of potential concern.

Key:

B = Analyte also was detected in blank analyses.

J = Estimated concentration.

 $\mu g/L = Micrograms per liter.$

^a United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 1×10^{-6} . Hazard quotient = 0.1.

INORGANICS RESULTS FOR NEW WELLS COAL STORAGE YARD JULY 1994 OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA (mg/L)

Analyte	AP-6518	AP-6519	AP-6520	AP-6521	AP-6522	AP-6523	AP-6524	AP-6524 (Duplicate)	Risk-based Concentration ^a	Background Concentration ^b
Total Arsenic	.0023	.0045	0.0078	.0025	0.024	.0084	0.00091	0.00063	0.000038	.072°
Dissolved Arsenic	.0015	.0043	.0068	.0021	.013	.0023	0.0081	.00094	0.000038	.020 ^c
Total Selenium	<.0005	<.0005	<.0005	<.0005	<.0005	<.0005	0.0036	0.0038	0.018	.002U
Dissolved Selenium	<.0005	<.0005	<.0005	<.0005	<.0005	<.0005	.0034	.0035	0:018	.002U
Total Zinc	<.005	.0064	<.005	<.005	<.005	<.005	0.0062	<.005	1.1	.097
Dissolved Zinc	.012	.018		.02		.012			1.1	.005U
Total Lead	<.001	<.001	.0068	.0016		<.001			.015	.066 ^c

NOTE: Highlighted areas indicate the comparison criteria used to determine whether analyte was a chemical of potential concern.

Key:

mg/L = Milligrams per liter.

U =

^a United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 1 × 10⁻⁷. Hazard quotient = 0.1.

COMPARISON OF VOC RESULTS 1993 VERSUS 1994 COAL STORAGE YARD

OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Volatile Organic	3595-	01	3595-	02	3595-03			
Compound of Concern (µg/L)	1993	1994	1993	1994	1993	1994		
Trichloroethene	56.0	11	7	9	< 5.0			
Methylene Chloride	6.0	<5.0	4.0	2 JB	< 5.0	< 5.0		
Trichlorofluoromethane	<5.0	<5.0	< 5.0	< 5.0	29.0	140		

Key:

B = Analyte also was detected in blank analysis.

J = Estimated detection limit.

 μ g/L = Micrograms per liter.

VOC = Volatile organic compound.

DIOXIN RESULTS FOR NEW WELLS COAL STORAGE YARD JULY 1994

(pg/L)

OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Compound	AP-5734	AP-6141	AP-5517	3595-03	3595-02	3595-01	AP-5509	AP-5508	AP-5735	AS-5510
2,3,7,8-TCDD	<11.6	<34.1	<4.9	<2.7	<4.8	<4.7	<5.2	<4.2	<4.1	<2.8
2,3,7,8-TCDF	34.7B	23.0B ^a	<3.7	<2.0	<3.5	<3.5	4.9B	5.3B	< 2.9	2.3B ^a
1,2,3,4,6,7,8-HpCDD	58.2	_	7.3	< 5.6	< 6.6	4.5 ^a	27.2	< 6.2	<7.4	< 5.1
1,2,3,4,6,7,8-HpCDF	57.0	49.8	<3.8	<2.9	<3.4	<3.4	9.7	<3.1	<3.9	<2.5
1,2,3,4,7,8,9-HpCDF	<18.4	<53.0	< 6.9	<5.2	< 6.2	< 6.2	7.2	< 5.6	<7.1	<4.5
1,2,3,4,7,8-HxCDD	<17.3	<49.0	< 6.7	<4.8	< 6.0	< 5.2	9.8	< 5.1	<5.9	<4.1
1,2,3,4,7,8-HxCDF	42.7	35.1 ⁸	<4.6	<3.1	<4.1	<4.0	9.1ª	<3.4	<4.3	<2.7
1,2,3,6,7,8-HxCDD	8.5 ^a	<41.2	< 5.6	<4.1	< 5.0	<4.4	9.3	<4.3	<4.9	<3.5
1,2,3,6,7,8-HxCDF	17.0	12.2 ²	<3.4	<2.3	<3.0	<3.0	8.1	<2.6	<3.2	<2.0
1,2,3,7,8,9-HxCDD	<15.6	<44.4	< 6.1	<4.4	< 5.4	<4.7	7.4 ^a	<4.7	<5.3	<3.7
1,2,3,7,8,9-HxCDF	11.3	<40.1	<5.5	<3.8	<4.9	<4.8	9.5 ^a	<4.2	<5.3	<3.3
1,2,3,7,8-PeCDD	<11.7	<34.6	< 5.6	<3.4	<5.3	<4.9	11.6	<4.5	<4.9	<3.1
1,2,3,7,8-PeCDF	<8.7	<24.1	<3.5	<2.1	<3.4	<3.2	9.3 ⁸	<2.7	<3.2	<2.1
2,3,4,6,7,8-HxCDF	15.0B ^a	22.8B	3.5B ^a	3.9B	4.3B ^a	5.2B ^a	11.7B	5.4B ^a	3.3B ^a	1.5B ^a
2,3,4,7,8-PeCDF	<8.4	20.3	<3.4	<2.0	<3.3	<3.2	8.8	<2.7	<3.1	<2.0
1,2,3,4,6,7,8,9-OCDD	269	337	11.4	<7.6	19.8	16.5 ^a	166	18.8 ^a	<10.4	10.7
1,2,3,4,6,7,8,9-OCDF	58.5	63.0 ^a	<7.8	<6.5	< 6.9	<5.5	17.3 ^a	<7.4	< 8.8	<5.2

DIOXIN RESULTS FOR NEW WELLS COAL STORAGE YARD JULY 1994

(pg/L)
OPERABLE UNIT 4
FORT WAINWRIGHT, ALASKA

Compound	AP-5511	AP-5736	AP-6144 (Duplicate)	AP-6144	WS-099	WS-119 (Duplicate)	WS-119	AP-6143	AP-6142	RBC	
2,3,7,8-TCDD	<4.1	<2.2	<2.6	11.4	<2.2	4.8	4.8 <2.7		<1.6	.6 .43	
2,3,7,8-TCDF	<3.4	3.2	<1.8	5.1	<1.6	<1.6	<2.0	3.1	<1.3	4.3	
1,2,3,4,6,7,8-HpCDD	<5.3	6.4	<4.7	< 8.2	<3.6	<3.6	<5.3	<3.3	<2.4	43	
1,2,3,4,6,7,8-HpCDF	<2.7	<1.9	<2.2	<3.6	<1.9	<1.8	<2.7	<1.7	<1.3	43	
1,2,3,4,7,8,9-HpCDF	<4.9	<3.4	<4.1	< 6.5	<3.5	<3.3	< 5.0	< 3.0	<2.3	43	
1,2,3,4,7,8-HxCDD	<4.9	<3.1	<3.4	< 6.0	<3.0	<2.8	<4.1	<2.6	<2.0	4.3	
1,2,3,4,7,8-HxCDF	<3.3	<2.1	<2.4	<3.8	<2.2	<2.0	<2.8	2.0	<1.5	4.3	
1,2,3,6,7,8-HxCDD	<4.1	<2.6	<2.9	< 5.0	<2.5	<2.4	<3.4	<2.2	<1.7	4.3	
1,2,3,6,7,8-HxCDF	<2.4	<1.5	<1.8	<2.8	<1.6	<1.5	<2.1	<1.4	<1.1	4.3	
1,2,3,7,8,9-HxCDD	<4.4	<2.8	<3.1	< 5.4	<2.7	<2.6	<3.7	<2.4	<1.8	4.3	
1,2,3,7,8,9-HxCDF	<4.0	<2.5	<3.0	<4.6	<2.6	<2.5	<3.4	<2.3	<1.8	4.3	
1,2,3,7,8-PeCDD	<4.3	<2.4	<2.8	<4.5	<2.3	<2.3	<3.1	<2.1	<1.6	0.86	
1,2,3,7,8-PeCDF	<2.9	<1.5	<1.8	<2.8	<1.4	<1.5	<1.9	<1.4	<1.0	9.86	
2,3,4,6,7,8-HxCDF	5.2B	2.8B ^a	5.2B	4.5B	<4.2B	4.9B	5.0B	2.3B	4.7B	4.3	
2,3,4,7,8-PeCDF	<2.8	<1.4	<1.8	<2.7	<1.4	<1.4	<1.8	<1.4	<1.0	0.86	
1,2,3,4,6,7,8,9-OCDD	27.4	36.8B	8.9B	<12.3	4.8B ^a	6.0B ^a	20.4B	10.3B ^a	3.7B ^a	430	
1,2,3,4,6,7,8,9-OCDF	6.1	9.2	< 5.4	< 10.4	<3.8	<3.9	9.0	3.6 ^a	<2.6	430	

Key at end of table.

19:JZ5901_S050-T6_14-06/22/95-D1

NOTE: Bold type indicates that analyte was detected. Highlight indicates that analyte concentration met or exceeded the risk-based concentration.

a Estimated maximum practical concentration.

Key:

pg/L = Picograms per liter.

B = Detected concentration was less than 20x the concentration detected in the corresponding blank.

Table 6-16

ANALYTES EXCEEDING BACKGROUND AND RISK-BASED CONCENTRATIONS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Analyte	Exceeds Background	Exceeds Risk-Based Concentration and Background
Inorganics		
Alumimum	SS, SB, SD	
Antimony	GW	GW
Arsenic	SD	SD
Barium	SS, SB, SD	SS, SB, SD
Beryllium	SS, SB, SD	SS, SB, SD
Cadmium	SS, SB, SD	SS
Chromium	SS, SB, SD	SD, SB
Cobalt	SS, SB, SD	
Copper	SS, SB, SD	SD
Iron	GW	GW
Lead	SD	
Manganese	SS, SB, SD, GW	SS, SB, SD, GW
Mercury	SS, SD	SD
Nickel	SS, SB, SD	
Silver	SS, SB	
Selenium	SS, SD	SS
Vanadium	SS, SB, SD	SS, SB, SD
Zinc	SB, SD	
Organics		
1,2,3,4,6,7,8,9-OCDD	SS, GW	
1,2,3,4,6,7,8,9-OCDF	SS, GW	
1,2,3,4,6,7,8-HpCDD	SS, GW	GW, SS
1,2,3,4,6,7,8-HpCDF	SS, GW	GW
1,2,3,7,8,9-HxCDF	SS	
1,2,3,4,7,8-HxCDD	SS, GW	GW
1,2,3,4,7,8-HxCDF	SS, GW	GW

Table 6-16

ANALYTES EXCEEDING BACKGROUND AND RISK-BASED CONCENTRATIONS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

		Exceeds Risk-Based Concentration and Background
Analyte	Exceeds Background	
1,2,3,6,7,8-HxCDD	SS, GW	GW, SS
1,2,3,6,7,8-HxCDF	SS, GW	GW
1,2,3,7,8,9-HxCDD	SS, GW	GW
1,2,3,7,8,9-HxCDF	GW	GW
1,2,3,7,8-PeCDD	SS, GW	GW
1,2,3,7,8-PeCDF	SS, GW	GW
2,3,4,7,8-PeCDF	GW	GW
2,3,4,6,7,8-HxCDF	SS	
2,3,7,8-TCDD	SS, GW	GW
2,3,7,8-TCDF	SS	GW
1,1-Dichloroethane	GW	
1,1,1-Trichloroethane	SB, GW	
1,2-Dichloropropane	SB	
1,2,4-Trimethylbenzene	SB	
1,3-Dichloropropane	SB	
1,3,5-Trimethylbenzene	SB	SB
2-Methylnaphthalene	SB	
4,4'-DDD	SS	
4,4'-DDE	SS, GW	
4,4'-DDT	SS, SB	SB
Acenaphthene	SD	
Acenaphtylene	SD	
Acetone	SD	
Anthracene	SD	
Aroclor 1260	SB	SB
Benzene	SB, GW	SB, GW
Benzo(a)anthracene	SD	SD
Benzo(a)pyrene	SD	SD

Table 6-16

ANALYTES EXCEEDING BACKGROUND AND RISK-BASED CONCENTRATIONS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Analyte	Exceeds Background	Exceeds Risk-Based Concentration and Background				
Benzo(b)fluoranthene	SD	SD				
Benzo(g,h,i)perylene	SD					
Benzo(k)fluoranthene	SD	SD				
bis(2-Ethylhexyl)phthalate	SB, SD, GW	GW				
Bunker c-range organics	SD, GW, SS	SS, SB, GW				
Chrysene	SD					
cis-1,3-Dichloropropene	SB					
cis-1,2-Dichloroethene	SB, GW	GW				
Dibromomethane	SB					
Dibenzo(a,h)anthracene	SD	SD				
Dibenzofuran	SD	SD				
Dichloroprop	SB					
Dieldrin	GW	GW				
Diesel No. 2	GW, SS	SS, SB, GW				
di-n-Butylphthalate	SS, SD, GW					
Diesel-Range Organics	SD	SS				
Ethylbenzene	SB, GW	SS, SB, GW				
Fluoranthene	SD					
Fluorene	SD					
Heptachlor	GW	GW				
Heptachlor epoxide	GW	GW				
Indeno(1,2,3-cd)pyrene	SD	SD				
Isopropylbenzene	SB					
m&p-Xylene	SB					
Methoxychlor	SD, GW					
Methylene Chloride	SS, SD, GW	GW				
n-Butylbenzene	SB					
n-Propylbenzene	SB					

ANALYTES EXCEEDING BACKGROUND AND RISK-BASED CONCENTRATIONS COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

		Exceeds Risk-Based Concentration and Background
Analyte	Exceeds Background	
Naphthalene	SB, SD	
o-Xylene	SB	
p-Isopropyltoluene	SB	
Phenanthrene	SD	
Pyrene	SD	
sec-Butylbenzene	SB	
Tetrachloroethene	SB, GW	
Toluene	SS, GW	SB, GW
Trichloroethene	SB, GW	
Trichlorofluoromethane	SS, GW	GW
Total Recoverable Petroleum Hydrocarbons	SD, GW	G₩
Xylenes	GW	SB, GW

Key:

GW = Groundwater.

mg/kg = Milligrams per kilogram.

pg/g = Picograms per gram.

SB = Subsurface soil.

SD = Sediment.

SS = Surface soil.

TOC = Total organic carbon.

CHEMICAL-SPECIFIC ARARS AND TBCS FOR GROUNDWATER COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

(mg/L)

Constituent	State ARARs ^a	TBCS
Antimony	0.006	0.0015 ^c /1.6 ^e
Manganese	0.05 ^d	0.018 ^c /0.05 ^b
bis(2-ethylhexyl)phthalate	0.006	0.0048 ^c
Dieldrin		4.2×10^{-6c}
Heptachlor	0.0004	2.3×10^{-6} c/3.8 × 10^{-6} ,e
Heptachlor Epoxide	0.0002	1.2×10^{-6c}
Methylene chloride	0.005	0.0041 ^c
Trichloroethene	0.005	0.005 ^e
BTEX	_	0.01 ^f
Xylenes	10	12 ^b /0.01 ^f
Ethylbenzenes	0.7	1.3 ^b /0.01 ^f
Toluene	1	0.75 ^b /0.01 ^f
Benzene	0.005	0.00036 ^b /0.005 ^e
Dioxin (2,3,7,8-TCDD)		$4.3 \times 10^{-10,b}$
Iron	0.03 ^d	1.0 ^e
Fuel		Failure of organoleptic test. No visible sheen, film, or discoloration.
cis-1,2,Dichloroethene	0.07	0.061 ^b
Trichlorofluoromethane		1.3 ^b /11 ^g

^a 18 Alaska Administrative Code 80.070 Maximum Contaminant Levels.

Key:

ARARs = Applicable or relevant and appropriate requirements.

BTEX = Benzene, toluene, ethylbenzene, and total xylene.

 $\mu g/L = Micrograms per liter.$

mg/L = Milligrams per liter.

TBCs = To be considered criteria.

b 40 Code of Federal Regulations 141.63 Secondary Maximum Contaminant Levels.

^C Risk-based concentrations equivalent to a cancer risk of 1E-06 or a hazard quotient of 0.1 (United States Environmental Protection Agency 1994).

d 18 AAC 80.070(b) secondary maximum contaminant levels.

^e Alaska Department of Environmental Conservation, 1991, Alaska Water Quality Standards Workbook.

f 18 AAC 70 Water Quality Standards value for BTEX is 10 μ g/L.

g Alaska Water Quality Standards Workbook, total for halomethanes is 11,000 μ g/L.

CHEMICAL-SPECIFIC TBCs FOR SOIL COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Constituent	ARARs	To Be Considered
DRO		(3) 100-2,000 mg/kg
Dibenzofuran	_	(1) Background or contaminant leaching assessment (2) 31 mg/kg
Residual-range petroleum hydrocarbons	_	(3) 2,000 mg/kg
Benzene	_	(3) 0.1-0.5 mg/kg
Arsenic	_	(1) Background or contaminant leaching assessment (2) 0.037 mg/kg
Barium	_	(1) Background or contaminant leaching assessment (2) 550 mg/kg
Beryllium	_	(1) Background or contaminant leaching assessment (2) 0.015 mg/kg
Cadmium		(1) Background or contaminant leaching assessment (2) 3.9 mg/kg
Chromium	_	(1) Background or contaminant leaching assessment (2) 39 mg/kg
Copper	_	(1) Background or contaminant leaching assessment (2) 290 mg/kg
Manganese	_	(1) Background or contaminant leaching assessment (2) 39 mg/kg
Mercury	_	(1) Background or contaminant leaching assessment (2) 2.3 mg/kg
Selenium	_	(1) Background or contaminant leaching assessment (2) 39 mg/kg
Vanadium	_	(1) Background or contaminant leaching assessment (2) 55 mg/kg
1,3,5-Trimethylbenzene	_	(1) Background or contaminant leaching assessment
4,4'-DDT	_	(1) Background or contaminant leaching assessment (2) 0.19 mg/kg
Benzo(a)anthracene	_	(1) Background or contaminant leaching assessment (2) 0.088 mg/kg
Benzo(a)pyrene		(1) Background or contaminant leaching assessment (2) 0.0088 mg/kg
Benzo(b)fluoranthene	_	(1) Background or contaminant leaching assessment (2) 0.088 mg/kg

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Table 6-18

CHEMICAL-SPECIFIC TBCs FOR SOIL COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Constituent	ARARs	To Be Considered
Benzo(k)fluoranthene	_	(1) Background or contaminant leaching assessment (2) 0.88 mg/kg
Dibenzo(a,h)anthracene	_	(1) Background or contaminant leaching assessment (2) 0.0088 mg/kg
Indeno(1,2,3-cd)pyrene	_	(1) Background or contaminant leaching assessment (2) 0.088 mg/kg
Dioxins (2,3,7,8-TCDD)	_	(1) Background or contaminant leaching assessment (2) 4.1 × 10 ⁻⁷ mg/kg
PCBs	_	(1) Background or contaminant leaching assessment (2) 0.0083 mg/kg

- (1) "Soils contaminated by hazardous substances other than crude oil or refined petroleum products must be cleaned to background levels or to levels shown through a contaminant leaching assessment to not lead to groundwater contamination through leaching nor pose a risk to potential surface receptors."
- (2) Risk-based concentration equivalent to a cancer risk of 1E-07 or a hazard quotient of 0.1 (United States Environmental Protection Agency 1994).
- (3) Interim Guidance for Non-UST Contaminated Soil Cleanup Levels, July 17, 1991, matrix scoresheet.
- (4) Forty CFR 761.120 PCB spill cleanup policy. The cleanup for soil in an unrestricted area is 10 parts per million (ppm) and 25 ppm in a restricted area.

Key:

DRO = Diesel-range organic.

mg/kg = Milligrams per kilogram.

PCB = Polychlorinated biphenyl.

TBCs = To be considered criteria.

UST = Underground storage tank.

MICROWELL ANALYTICAL RESULTS COAL STORAGE YARD

 $(\mu g/L)$

OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Analyte	No. of Samples Analyzed/ Detected	Minimum Result	Maximum Result	Location of Maximum Result	Mean Conc.	Risk- based Conc. ^a
1,1,1-Trichloroethane (TCA)	30/3	3.8	65	PS-4	30.2667	_
1,1-Dichloroethane	30/2	1	8.1	PS-2	4.55	81
1,2-Dichloroethane	30/1	0.5	0.5	PS-2	0.5	0.12
Benzene	30/17	0.5	800	PS-4	54.6	0.36
cis-1,2-Dichloroethene	30/5	0.7	6.8	PS-2	2.2	6.1
Ethylbenzene	30/11	1	650	PS-4	84.4545	130
Tetrachloroethene (PCE)	30/3	1.7	4.3	PS-4	2.6	6.1
Toluene	30/9	1	2,300	PS-4	348.667	75
Total Xylenes	30/12	2	3,200	PS-4	379.883	1,200
Trichloroethene (TCE)	. 30/6	0.6	1.4	PS-4	0.91667	

^a United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 1×10^{-6} . Hazard quotient = 0.1.

Key:

- = Not analyzed.

Conc. = Concentration.

 μ g/L = Micrograms per liter.

MICROWELL ANALYTICAL RESULTS DEPTH PROFILE - SELECTED ANALYTES OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

 $(\mu g/L)$

Well Number			PS-1					PS-2					PS-3					PS-4		
Analyte	В	E	T	X	TCE	В	E	T	X	TCE	В	E	T	X	TCE	В	E	Т	X	TCE
Depth (Feet)																				
19	0.5 U	1 U	1 U	1 U	0.5 U	1.2	1 U	1 U	3.6 U	0.7	2.6	2	1 U	7 U	0.5 U					
29	0.5 U	1 U	1 U	1 U	0.9	0.6	1 U	1 U	2	1.1	0.8	2	1 U	1 U	0.5 U	800	650	2300	3200	0.5 U
39	0.6	1 U	1 U	1 U	0.8	1.4	1 U	1 U	1 U	0.5 U	0.5 U	1 U	1 U	1 U	0.5 U	98	160	570	790	1.4
49	0.7	1 U	1 U	1 U	0.5 U	0.6	1 U	1 U	1 U	0.5 U	1.2	1 U	1 U	1 U	0.5 U	17	66	220	350	0.6
59	0.5 U	1 U	1 U	1 U	0.5 U	0.5 U	1 U	1 U	1 U	0.5 U	0.5 U	1 U	1 U	1 U	0.5 U	0.5 U	21	27	91	0.5 U
69						0.6	ΙU	1 U	1 U	0.5 U	0.5 U	1 U	1 U	1 U	0.5 U	0.8	8	7	25	0.5 U
70											0.5 U	1 U	1 U	1 U	0.5 U					
79						0.5 U	1 U	1 U	1 U	0.5 U						0.5 U	7	5	32	0.5 U
89						0.8	1 U	1 U	1 U	0.5 U						0.8	10	7	48	0.5 U
98									-							0.5 U	2	1 U	7	0.5 U
108	!															0.5 U	1 U	1 U	3	0.5 U

Note: Some depths have been rounded for presentation purposes. Actual depths may vary by up to one foot.

Key:

Detected analyes are listed in bold type.

B = Benzene

E = Ethylbenzene

T = Toluene

X = Total Xylenes

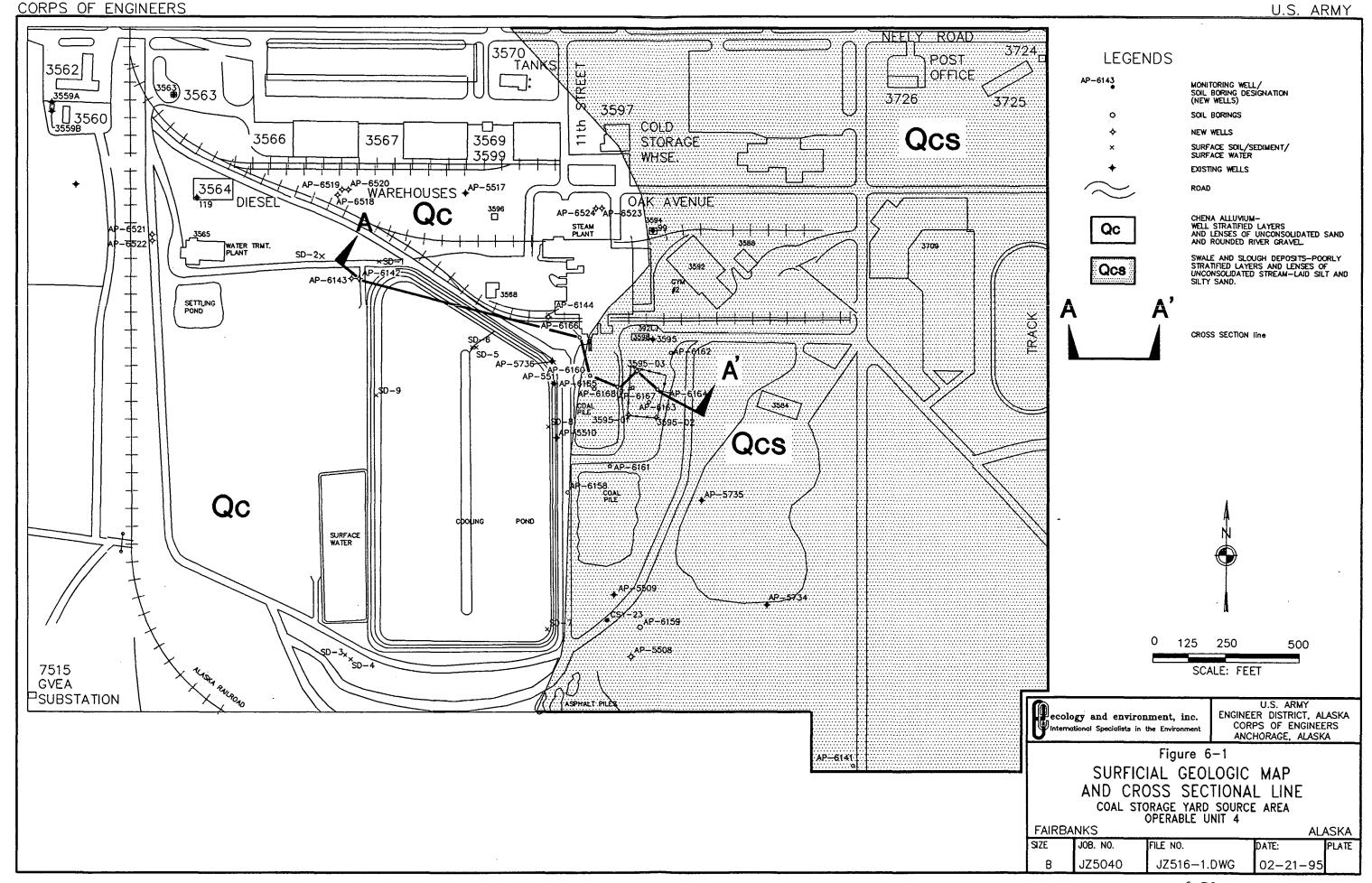
TCE = Trichloroethene

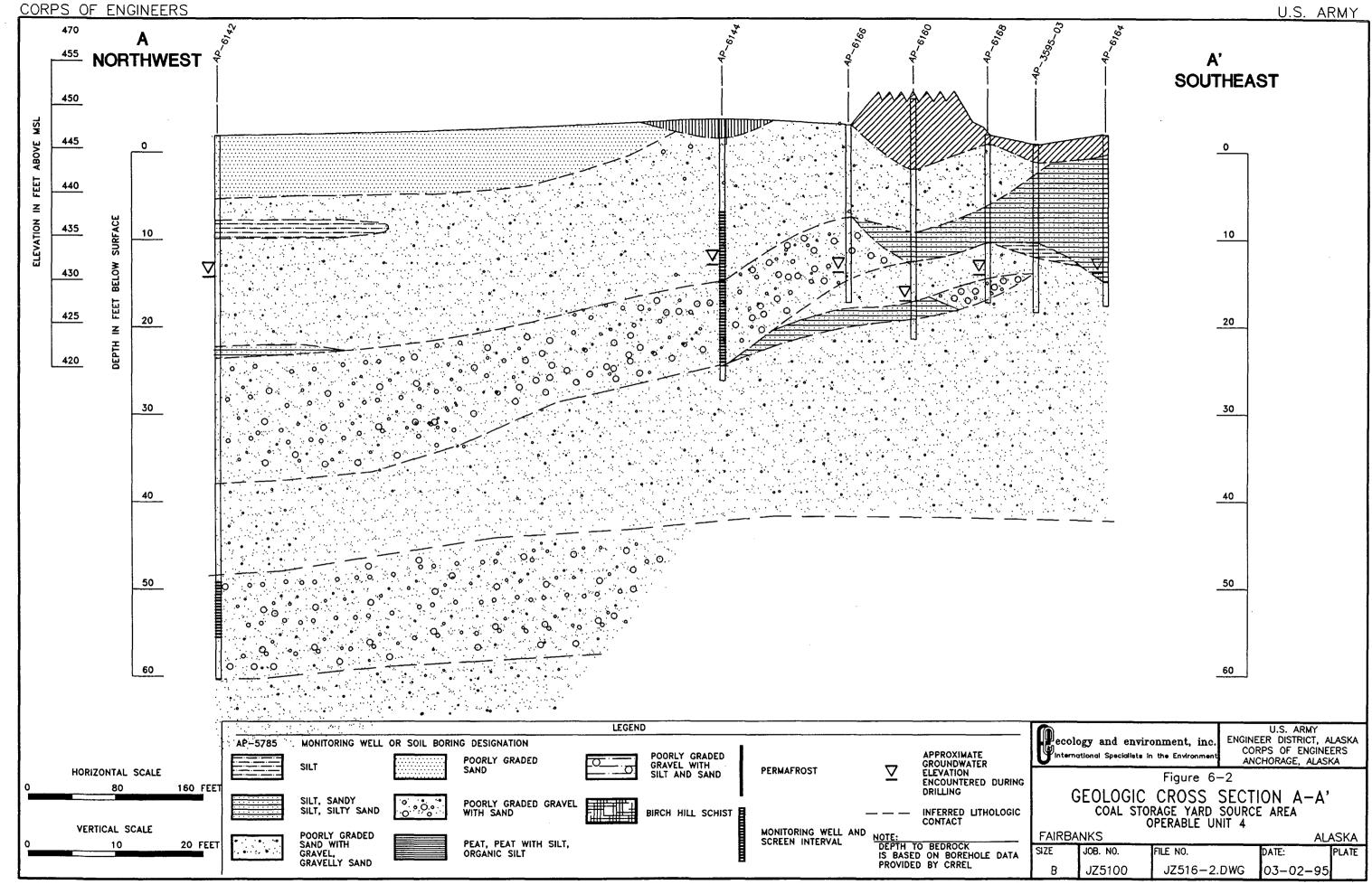
-- = Not analyzed.

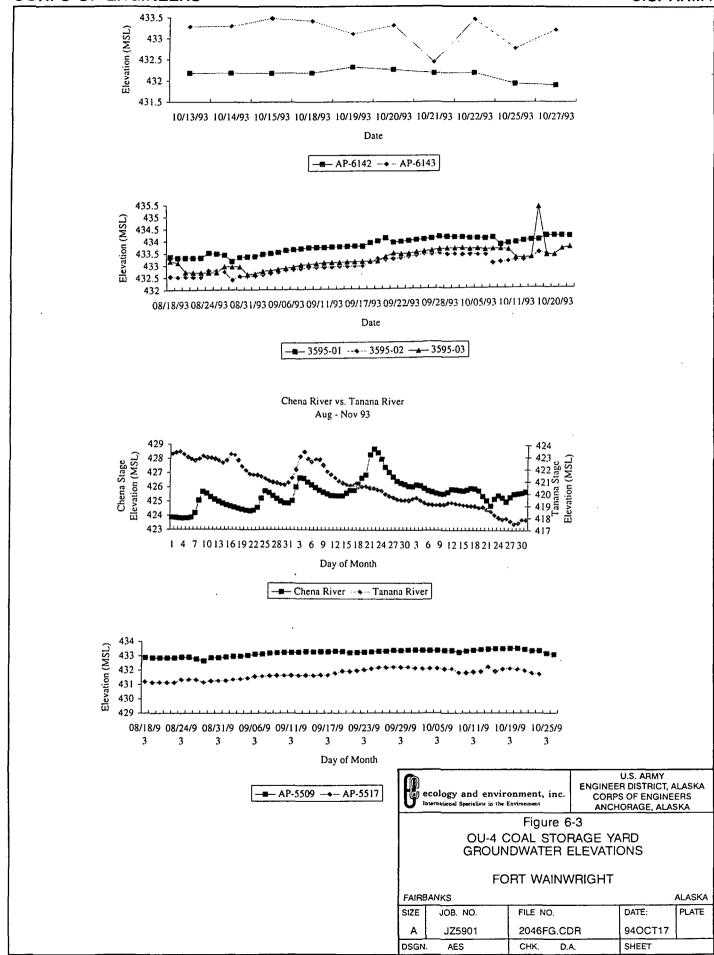
U = Analyte not detected at the specified quantitation limit.

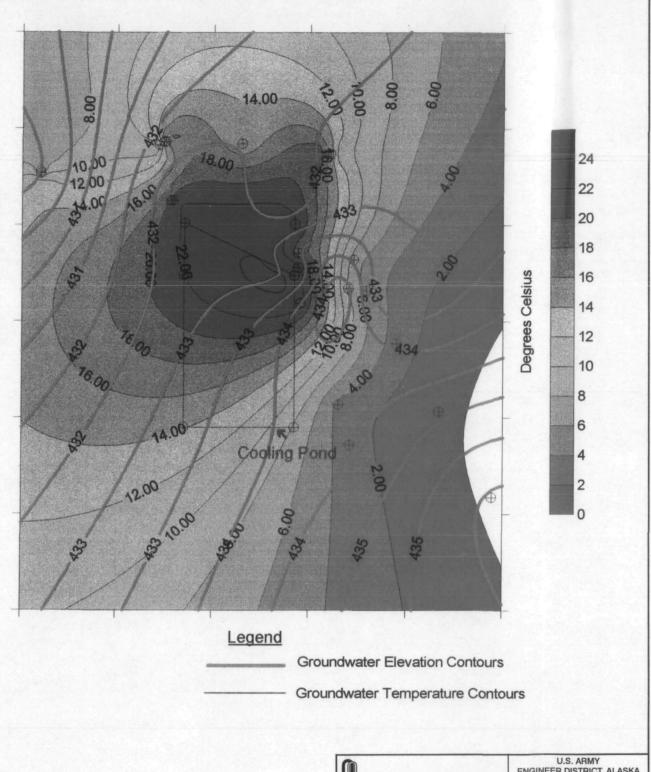
 μ g/L = Micrograms per liter.

11 5 4 0

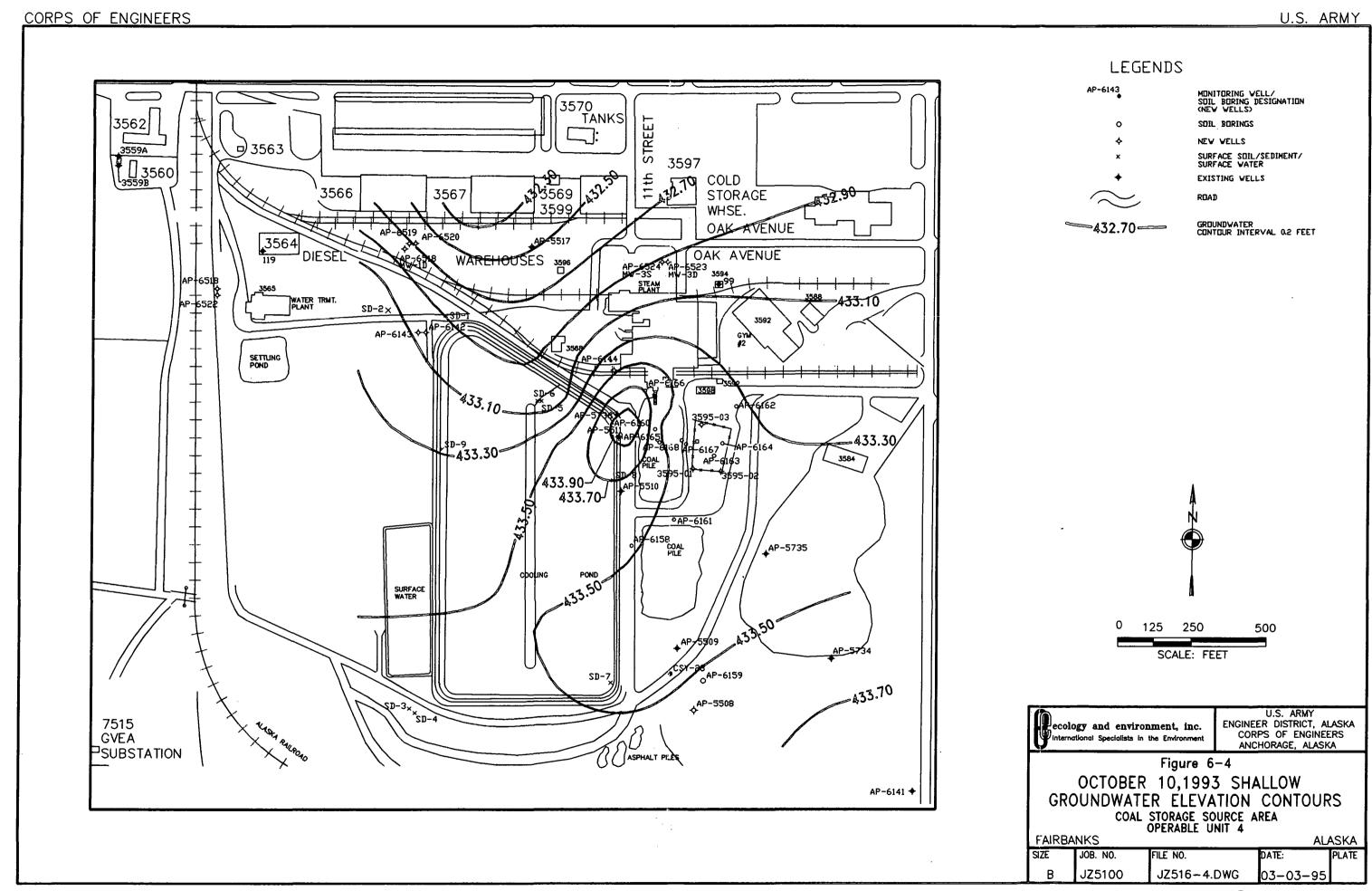


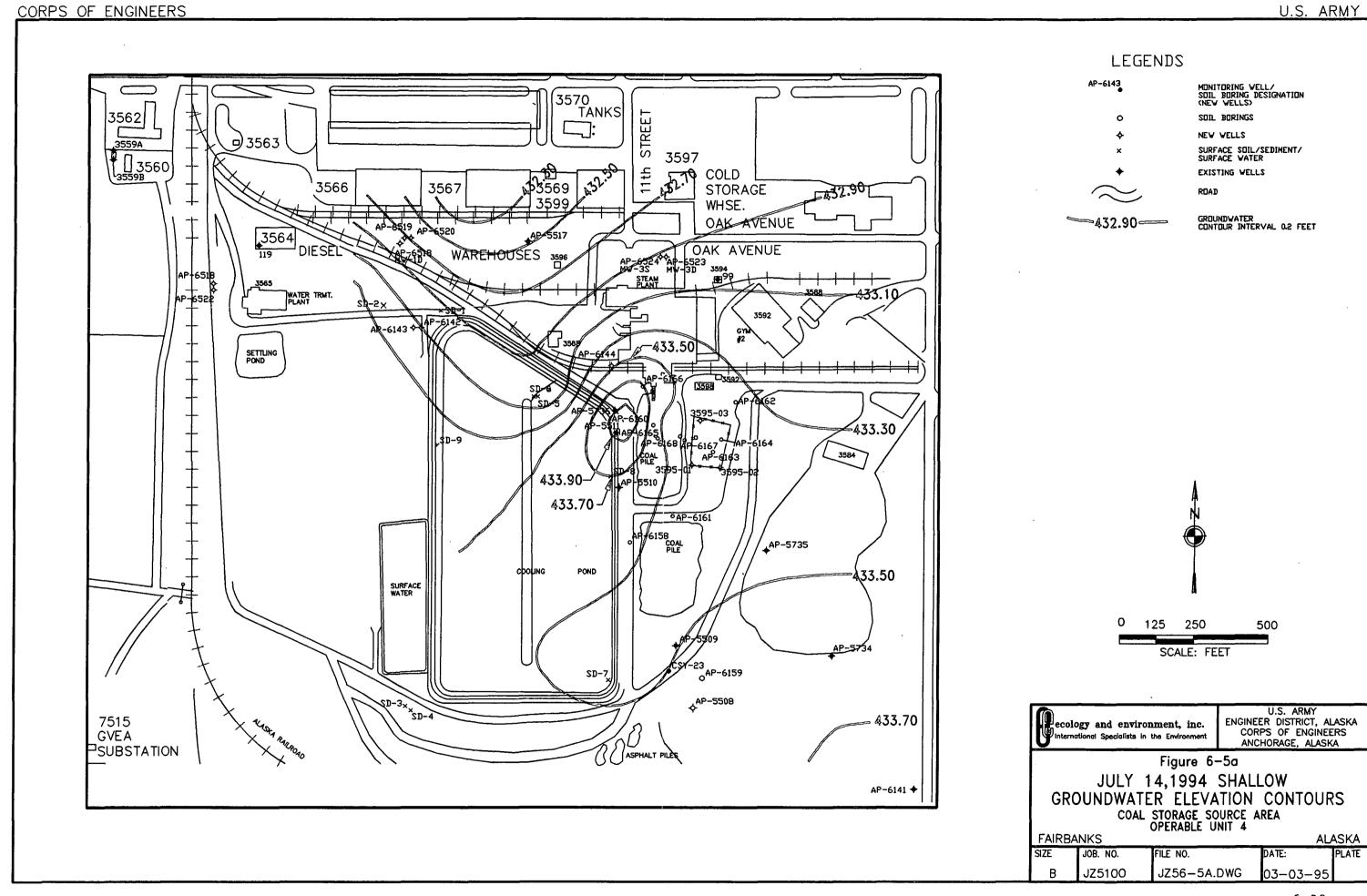


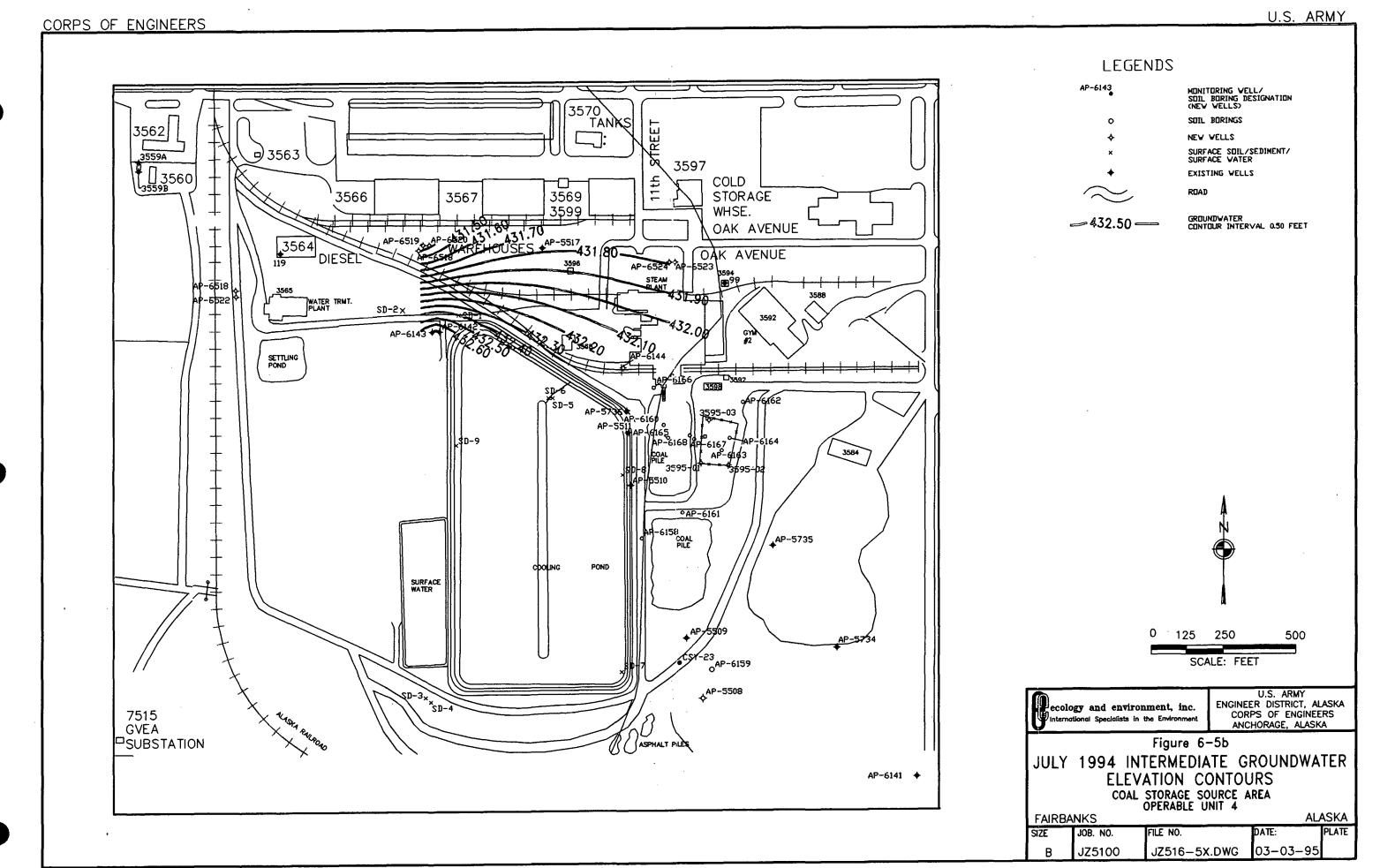




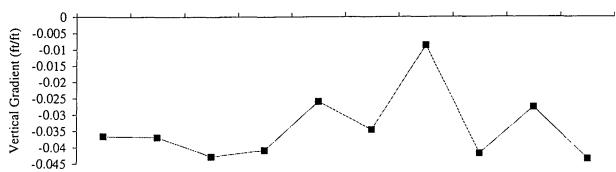
	cology and env ternational Specialists in t		CORPS OF ENGINEERS ANCHORAGE, ALASKA		
		Figure 6-	-3a		
1993	COAL ST		PERATURE CONT D SOURCE AREA VRIGHT		
FAIRB	ANKS			ALASKA	
SIZE	JOB. NO.	FILE NO.	DATE:	PLATE	
A	JZ5901		94NOV8		
DSGN		CHK	SHEET	SHEET	







+ gradients reflect upward groundwater movement
- gradients reflect downward groundwater movement



10/13/93 10/14/93 10/15/93 10/18/93 10/19/93 10/20/93 10/21/93 10/22/93 10/25/93 10/27/93

Date

AP-6142/AP-6143



U.S. ARMY
ENGINEER DISTRICT, ALASKA
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

Figure 6-6 OU-4 COAL STORAGE YARD VERTICAL GRADIENTS

FORT WAINWRIGHT

 FAIRBANKS
 ALASKA

 SIZE
 JOB. NO.
 FILE NO.
 DATE:
 PLATE

 A
 JZ5901
 2047FG.CDR
 94OCT17

 DSGN.
 AES
 CHK.
 D.A.
 SHEET

Anions

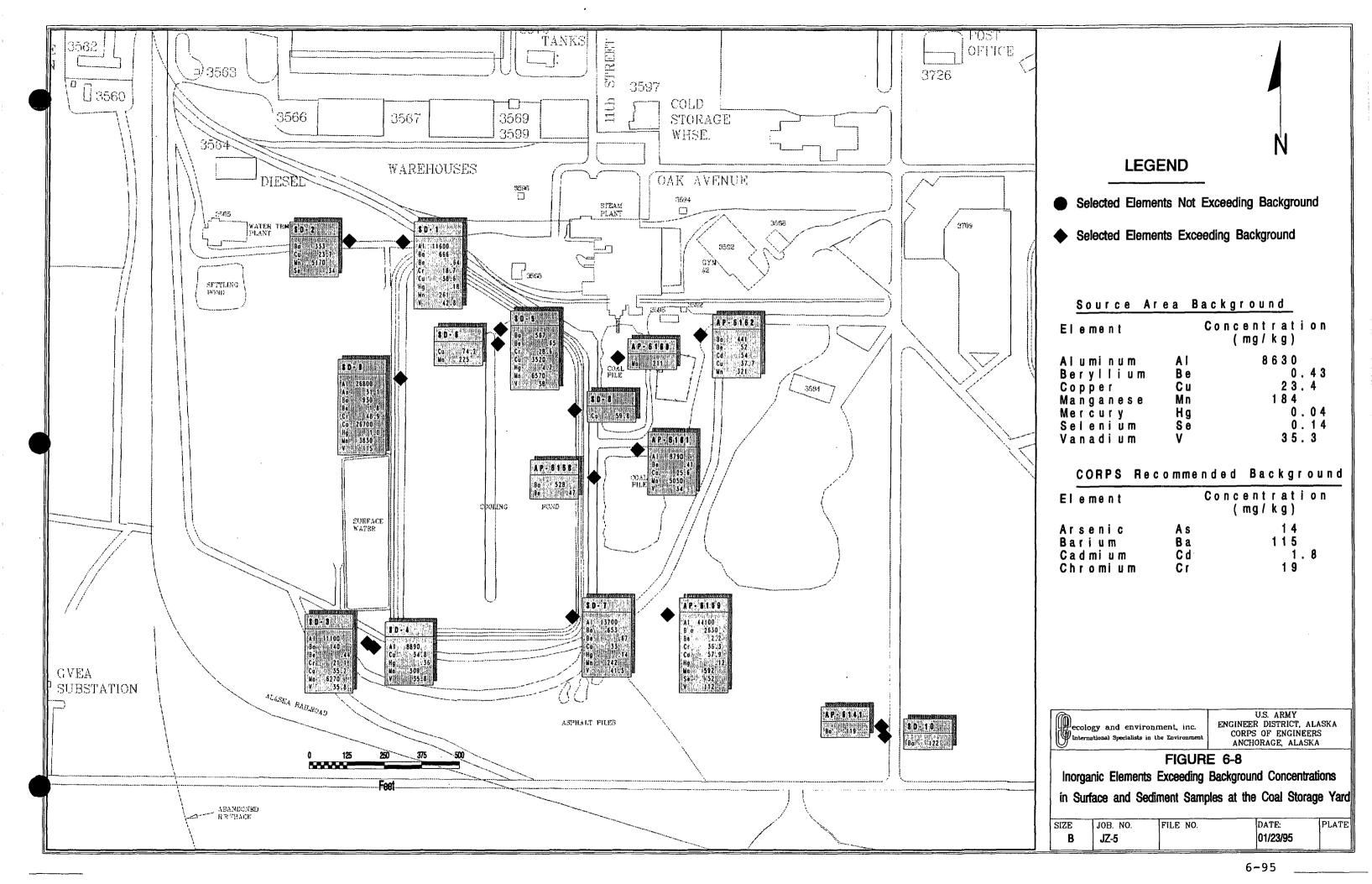
Cations

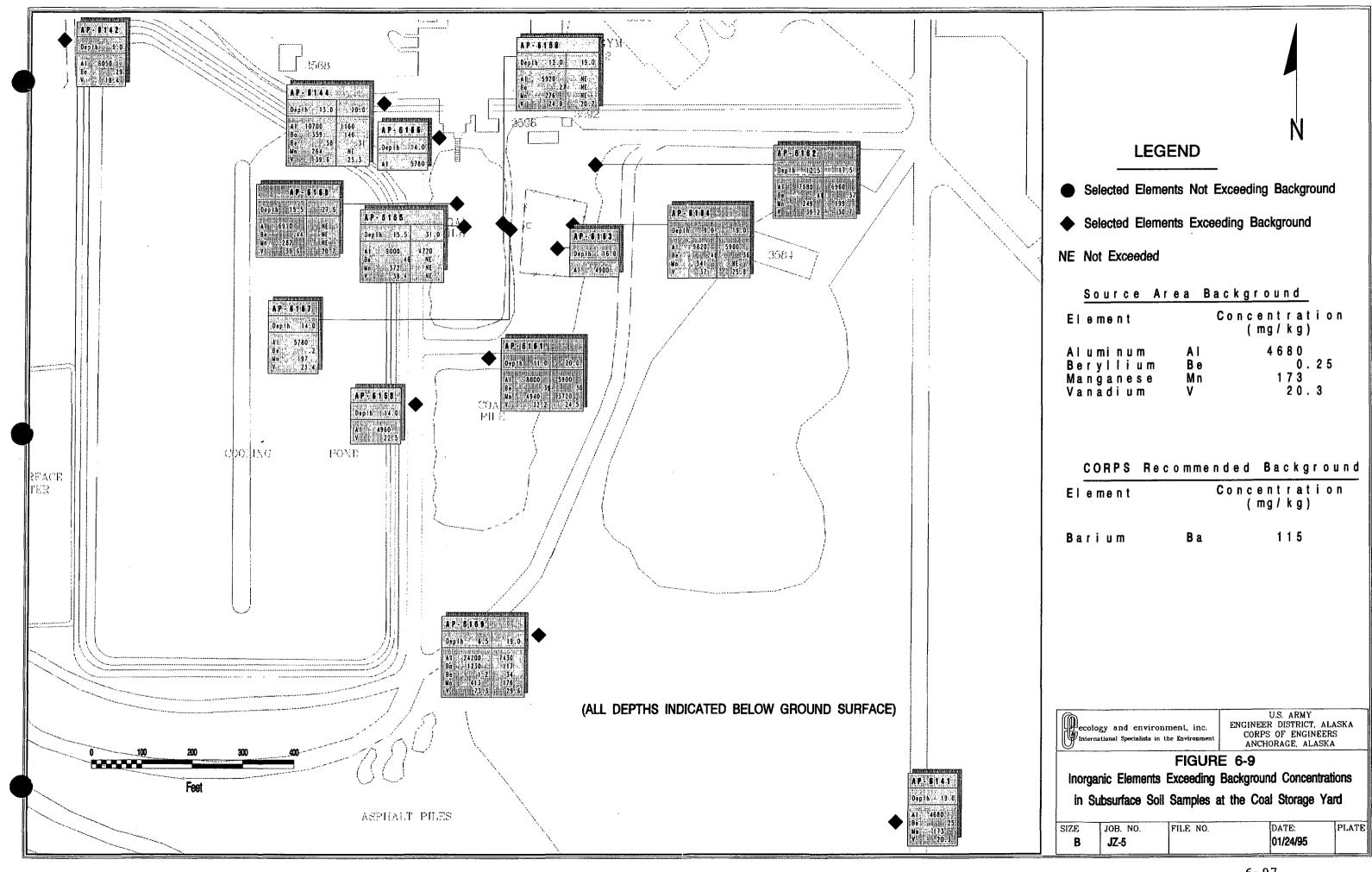
% mEq/l

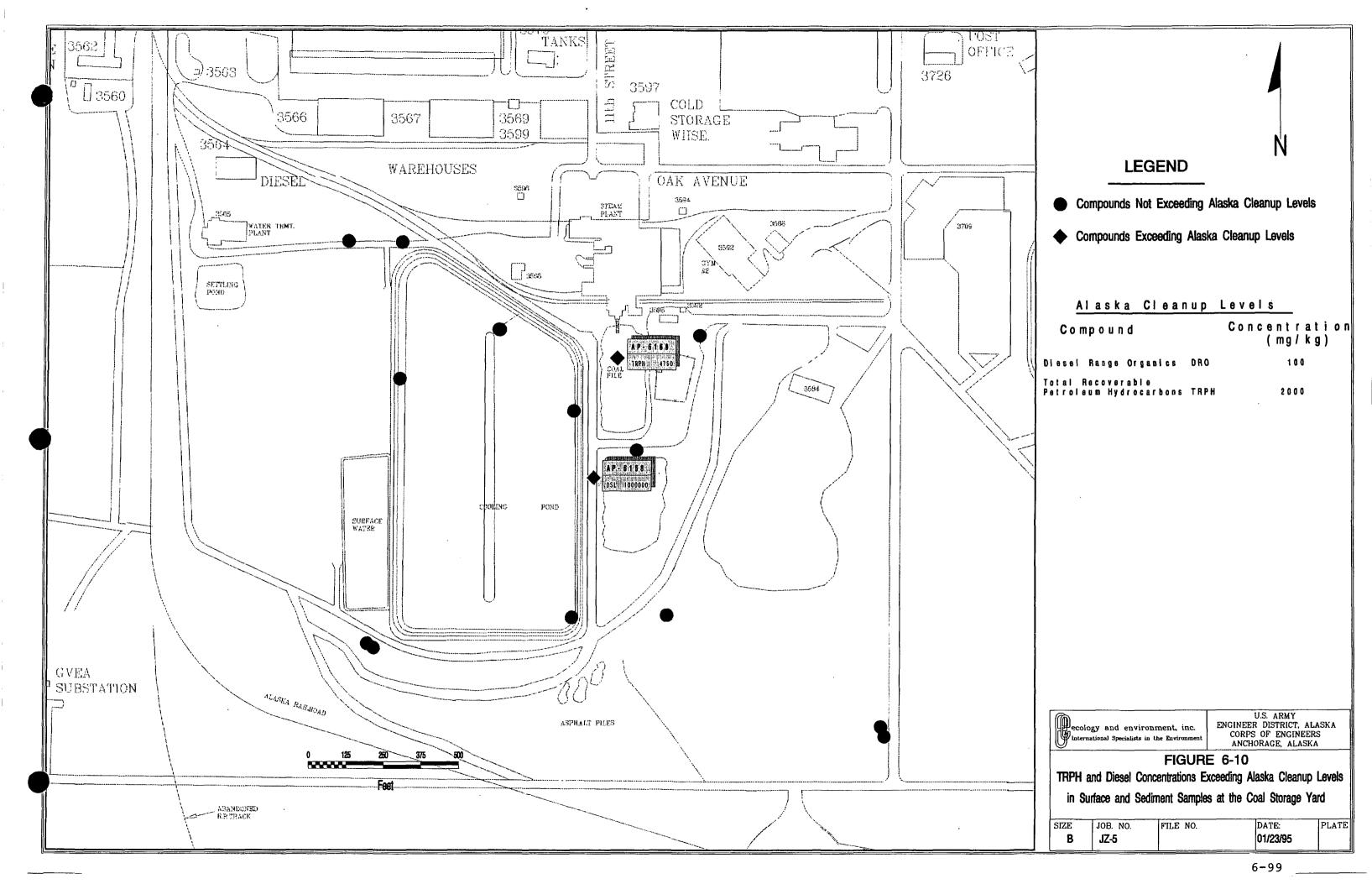
U.S. ARMY ENGINEER DISTRICT, ALASKA CORPS OF ENGINEERS ANCHORAGE, ALASKA

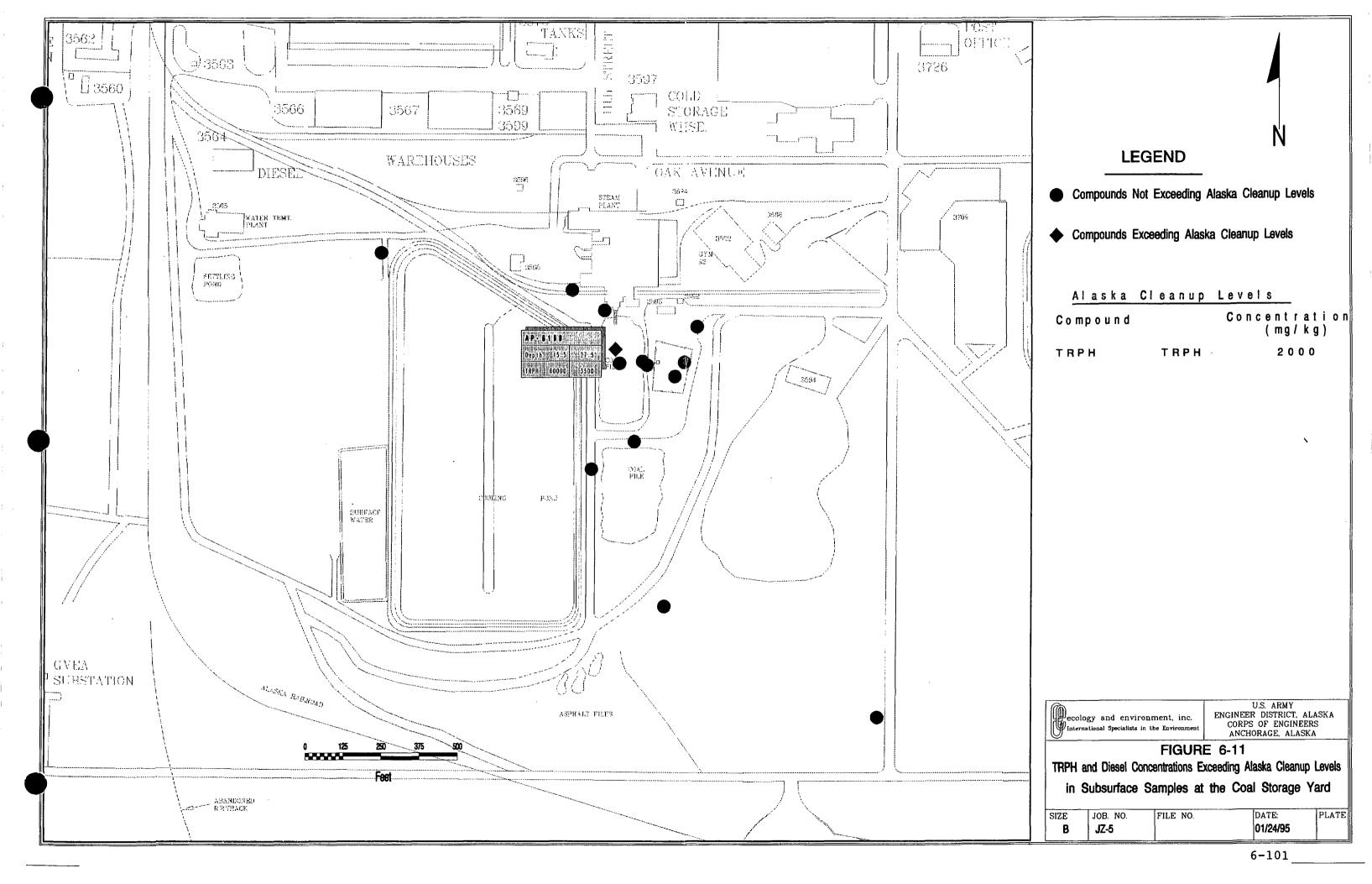
COAL STORAGE YARD HYDROGEOCHEMISTRY STIFF AND PIPER DIAGRAMS

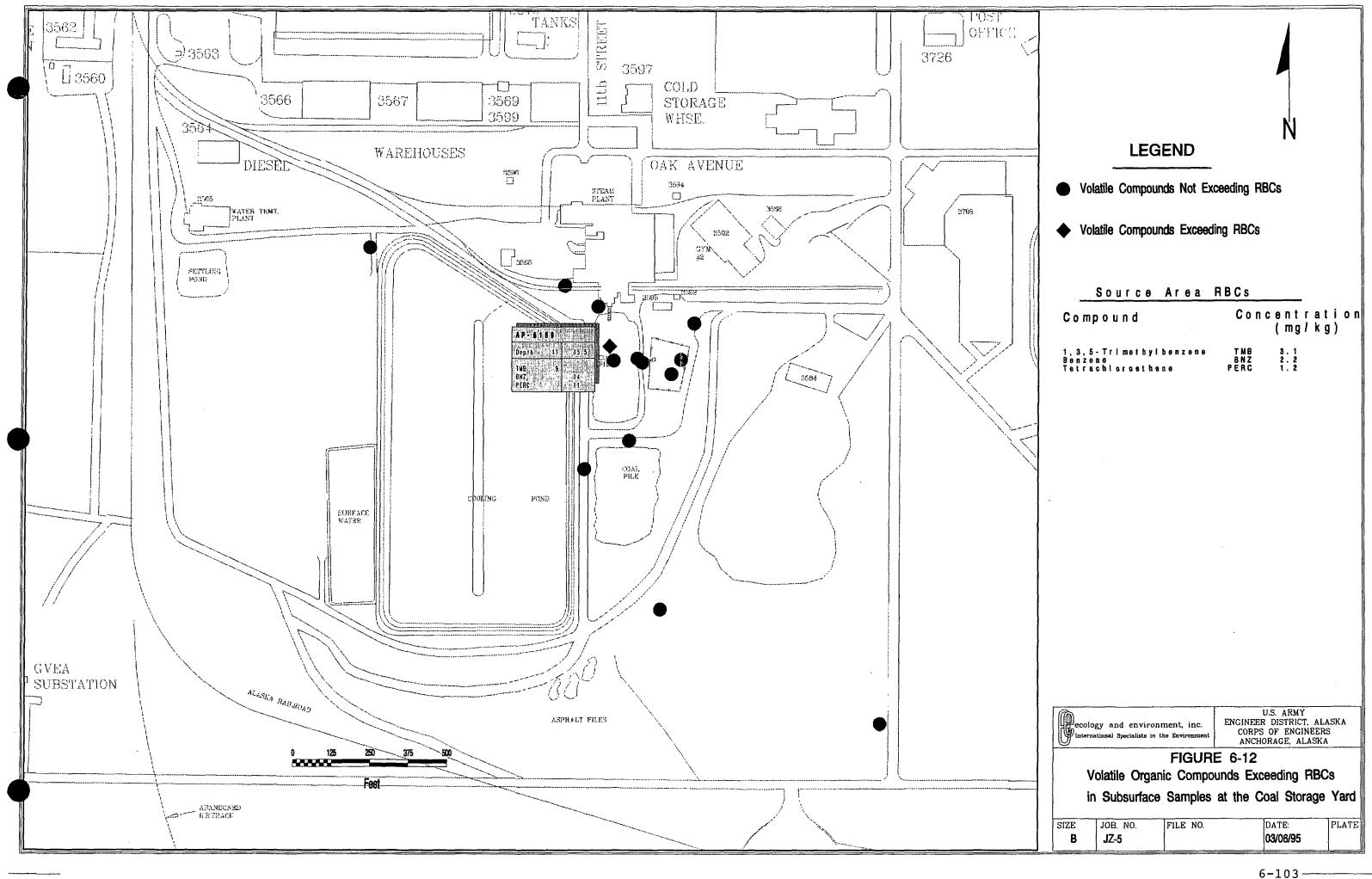
FORT WAINWRIGHT								
FAIRBANKS				ALASKA				
SIZE	JOB. NO.	FILE NO.	DATE:	PLATE				
Α	JZ5901	2018FG.CDR	94OCT6					
DSGN	. AES	CHK. J.R.	SHEET	_				

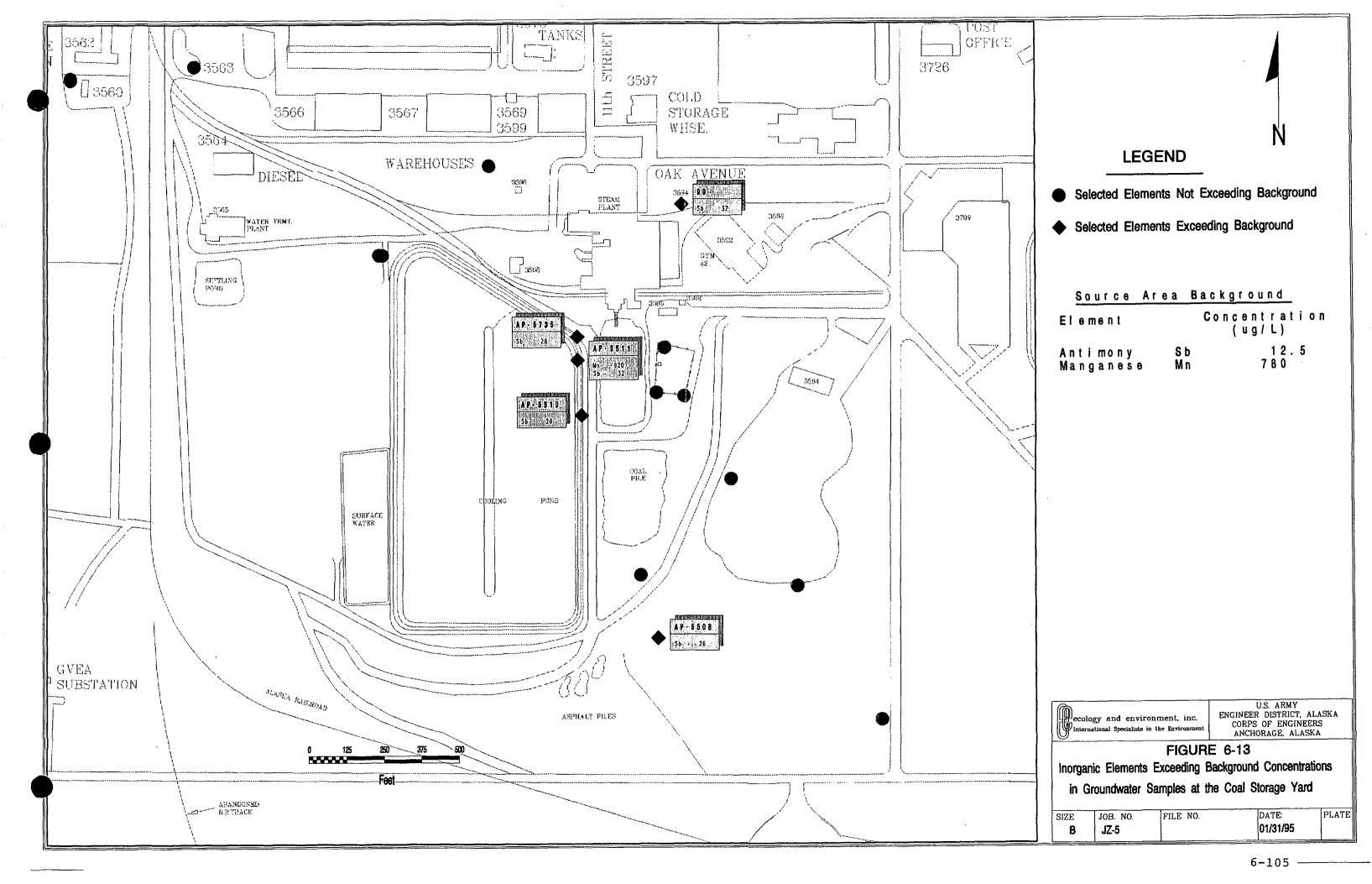


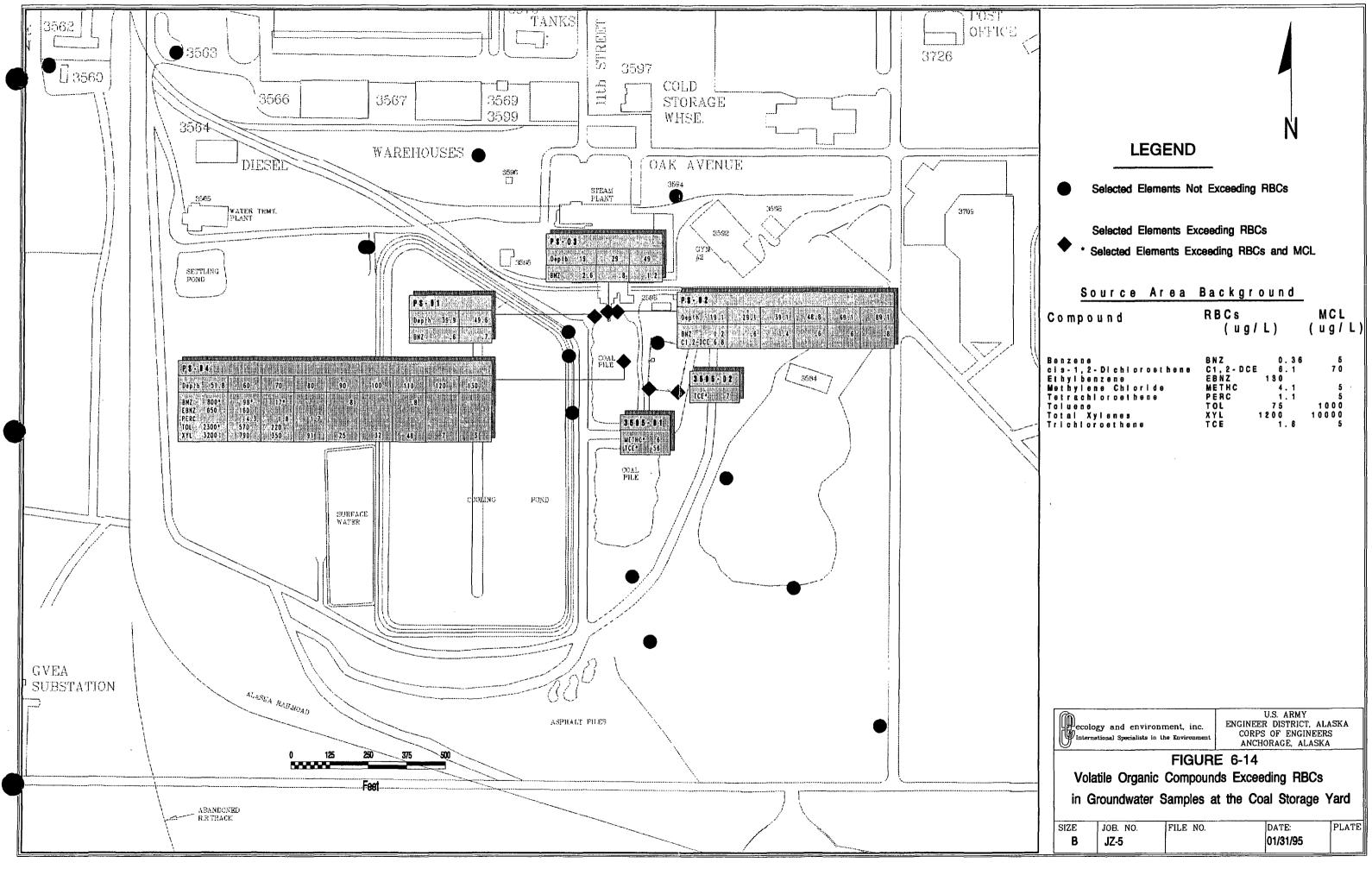


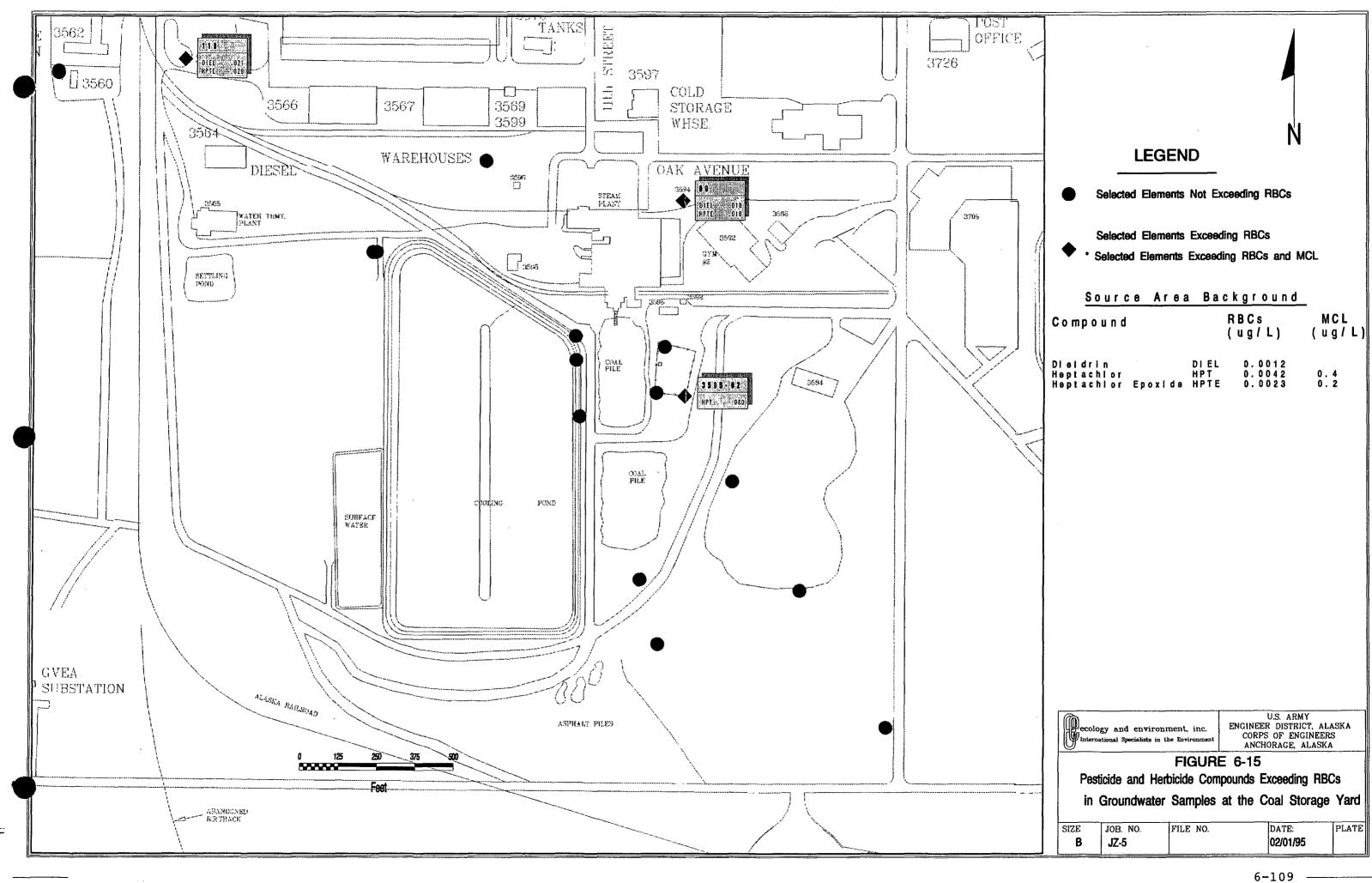


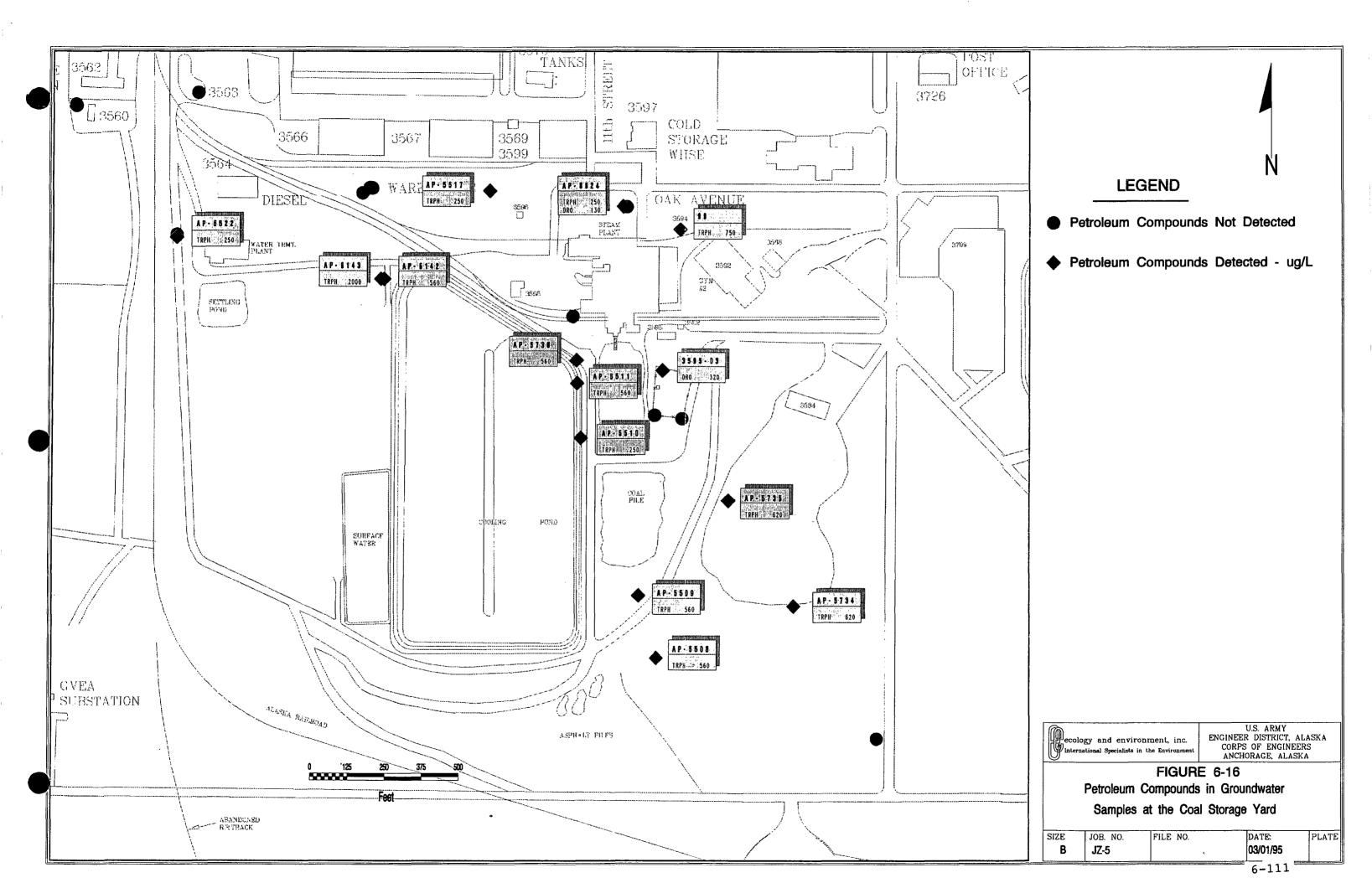


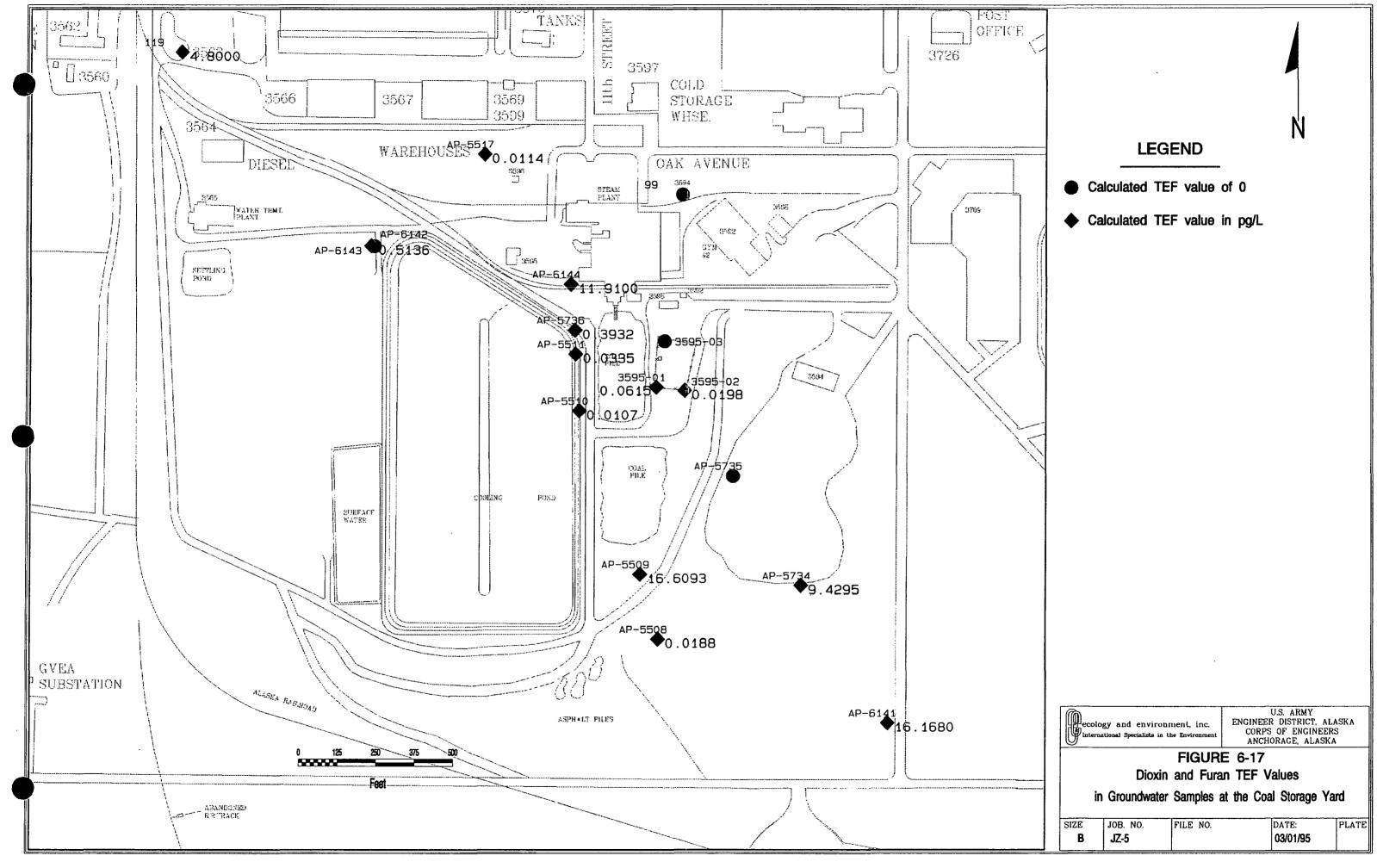












7. FIRE TRAINING PITS SOURCE AREA

7.1 PHYSICAL CHARACTERISTICS OF THE FIRE TRAINING PITS SOURCE AREA

The following section presents the data collected from RI activities for the FTPs. For descriptive purposes the FTPs Source Area is defined by a broad vegetated area consisting of dirt access roads used for military exercises, and cleared areas previously determined to be locations of former fire training exercises (see Figure 1-4). FTP-3A is the largest of the cleared areas and is partially surrounded by a fence. FTP-3B is the second cleared area less than a mile east of FTP-3A. A third area of investigation was identified as the depression north of the access road, which is northwest of FTP-3B. This area is vegetated and is partially surrounded by a berm to the north.

Data and discussions regarding characterization of the FTP source area, including data obtained from previous investigations, are presented in four sections. The source area investigations and characterization or media were based on soil boring and monitoring wells completed during 1993 and 1994 activities, as indicated in Table 7-1. The first section discusses the physical characteristics of the FTPs as defined by lithologic descriptions of surface and subsurface soils, as well as characterizing groundwater occurrence and hydraulic parameters. The second section discusses the nature of contamination determined from analytical work, and is followed by a section that describes the extent of contamination. The final section discusses the chemical specific ARARs appropriate for the FTPs.

7.1.1 Surface Soil and Sediments

Fifty-four surface soil locations were sampled during the 1993 field activities and six surface soil locations were sampled during the 1994 field activities. Analytical results for surface soil samples collected during the 1993 and 1994 field activities are discussed in

Section 7.2. Surface soil sample locations for the FTPs Source Area are identified in Figure 7-1. Sediment samples were collected in the drainage swales north and southwest of the FTPs Source Area where surface water runoff from the FTP would likely be concentrated. As indicated previously, water was not encountered in any of the drainage swales, therefore, these samples were actually surface soil samples but were identified as sediment samples.

In general, FTP-3A and FTP-3B have a light, vegetative cover of weeds, grasses, and wild strawberry plants. Localized unvegetated areas were identified at soil boring locations AP-6170 and AP-6172 at FTP-3A. At these cleared areas, oil staining and disturbed soil was observed. Figure 7-1 presents the distribution of surface soil types at the FTPs Source Area.

7.1.2 Subsurface Soil

During the 1993 field activities, a total of 20 soil borings were drilled at the FTPs Source Area. Thirteen borings were completed as monitoring wells. Analytical results for subsurface soil samples collected are discussed in Section 7.2.

As indicated previously, soil borings were advanced until groundwater was encountered at an average depth of approximately 15 feet BGS. Borings AP-6169, AP-6170, AP-6171, AP-6172, AP-6173, and AP-6174 were completed in known fire training areas of FTP-3A. Boring AP-6175 was completed in the depression north of the access road. Soil borings were not completed at FTP-3B; however, subsurface soil data were obtained from soil data obtained from monitoring wells AP-6149, AP-6150, and AP-6148.

Soil borings designated for monitoring well installation were advanced to approximately 30 feet BGS and the screened interval was positioned to bracket seasonal fluctuations in the water table. These wells are referred to as shallow wells. One deep (AP-6156) and one shallow (AP-6155) piezometer were completed to 100 feet BGS and 15 feet BGS, respectively. A shallow monitoring well (AP-6157) originally scheduled for completion to 30 feet BGS was actually installed at 25 feet BGS because of permafrost encountered at 22 feet BGS. Wells AP-6145, AP-6153, and AP-6154 were installed to investigate potentially contaminated areas of FTP-3A, while AP-6146 was completed to provide background soil information for FTP-3A. Wells AP-6148, AP-6149, and AP-6150 were installed to investigate potentially contaminated areas of FTP-3B, while AP-6147 was installed to provide background soil information for FTP-3B. Wells AP-6151 and AP-6152 were installed to

provide information on the extent of soil contamination downgradient of FTP-3B. Refer to Table 7-2 for a complete list4 of monitoring wells and soil borings completed.

Subsurface soil characterized on cross section A-A' (see Figure 7-2), which was generated from a northwest-southeast transect across FTP-3A consists of a range of poorly-graded sand, silty sand, and silt from ground surface to 45 feet BGS. This cross section typifies the subsurface lithology for the FTP Source Area where soil borings were completed. Underlying the silty sand and silt soil is poorly-graded gravel with sand and a gravelly sand with few traces of silt. The gravel appears to thicken to the southeast. The base of the poorly-graded sand was not defined by the deepest borehole (AP-6156), which extends to 100 feet BGS. Permafrost was encountered only in AP-6157 at a depth of approximately 22 feet BGS.

To provide information for a potential treatability study and for selecting remedial alternatives, physical parameter tests were conducted on subsurface soil collected from two of the soil borings (two depth ranges per selected borehole) and four surface soil samples (from soil boring locations). The parameters included percent moisture, specific gravity, grain size, moisture content, and Atterberg limits. Grain-size analysis was conducted using ASTM D-2487 and TM5-818-2 methods. Table 7-2 compares the laboratory ASTM D-2487 classification (i.e., SP or poorly-graded sand) with E & E's field geologist soil classification, and includes the borehole location and the approximate depth of each soil sample.

7

7.1.2.1 Ground-Penetrating Radar

A GSSI SIR System 10A GPR unit was used to investigate the FTPs Source Area and provide additional subsurface information. Initially, a GPR survey was completed to characterize permafrost at the Landfill Source Area; since equipment was available, the GPR unit was used along a transect across FTP-3A from locations AP-6172 to AP-6170. Results of the GPR survey at FTP-3A revealed some identifiable horizontal subsurface features that appeared to match lithology differences in the soil borings. The subsurface features appeared to correlate to the different lithologic units encountered during the drilling. In general, the GPR transects revealed no additional information other than that already obtained from the drilling of the monitoring wells and soil borings.

7.1.3 Groundwater

In addition to the monitoring wells installed during field activities (described above), the groundwater investigation program plan (i.e., management plan) included use of two previously installed monitoring wells or piezometers (AP-5295 and AP-5312) to provide groundwater elevations; however, the wells could not be located. Analytical results for groundwater samples collected from monitoring wells installed during the 1993 field activities at the FTPs Source Area are discussed in the Section 7.2.4.

Following installation, E & E personnel marked the monitoring wells with stakes for location by the Corps surveyors. All of the borings, monitoring wells, and selected locations of sediment and surface samples were surveyed for elevation and for northing and easting coordinates. The corresponding boring and monitoring well coordinates, and elevations for soil borings, monitoring wells, and piezometers are listed in Table 2-7.

7.1.3.1 Groundwater Elevations

Two aquifer zones were targeted for characterization during the RI: a shallow unconfined aquifer and a confined or semi-confined deeper aquifer. The two aquifers exist as a single aquifer in the FTPs Source Area as no distinct lithologic changes, extensive permafrost, or bedrock were identified in which a confining influence could exist.

The groundwater typically was encountered at 15 feet BGS or less. Groundwater elevation graphs (from 1993 data for one shallow [AP-6155] and one deep monitoring well [AP-6156]) located northwest of FTP-3A are presented in Figure 7-3. Groundwater elevations for all of the FTPs Source Area monitoring wells are included on a spreadsheet in Appendix C. Changes in casing elevation were not noted during 1994 field activities after the 1993 winter season.

Monitoring wells were completed in early October 1993, and measurements were taken following completion. The data indicate that the water level peaked in late September 1993 which is consistent with trends observed in the area and with water levels recorded at the USGS well 113 which is screened from 100 to 113 feet BGS.

7.1.3.2 Groundwater—Surface Water

Data from the FTPs Source Area wells suggest a correlation between high stage level of flow at the Chena and Tanana rivers and the highest groundwater elevation recorded at

FTPs Source Area wells, with a few days of lag time between peaks in groundwater elevations. This lag represents the time required for groundwater to flow through the aquifer system. This observation is consistent with groundwater elevation fluctuations observed in USGS well 113 and in the Tanana and Chena rivers stage elevations as discussed in Section 3.

7.1.3.3 Groundwater Flow Direction and Gradients

The groundwater elevation contours for the shallow aquifer zone (i.e., groundwater interface) determined during the 1993 field event is presented in Figure 7-4. Groundwater flow in the shallow aquifer measured during 1993 was west-northwest toward the Chena River, coincident with the regional flow expected in the Fort Wainwright area. Deeper aquifer (i.e., 100 feet BGS) groundwater flow could not be determined since only one deep monitoring well is present at the FTPs Source Area. However, based on Fort Wainwright groundwater monitoring data, groundwater is believed to follow the regional groundwater flow to the west-northwest.

The average horizontal groundwater gradient across the site in the shallow aquifer zone is estimated at approximately 0.0016 feet (8.4 ft/mile) for 1993 field event. The gradient was established between AP-6147 and AP-6155. The groundwater gradient for the 1993 field periods likely represents the end of seasonal high groundwater elevations based on historical groundwater data from the Fort Wainwright area.

A comparison of paired monitoring wells AP-6155 and AP-6156 was performed to identify vertical groundwater gradients at the FTPs Source Area. Vertical hydraulic gradients varied from approximately 0.0008 to 0.0014 feet upward from the deeper aquifer to the shallow aquifer for measurements made during the 1993 field activities (see Figure 7-5). In general, an upward gradient was maintained at the monitoring well nest during the 1993 field event. The vertical gradient fluctuations probably coincide with the rise and fall of the Chena and Tanana rivers stage, representing recharge and discharge of the aquifer, diurnal and other time-dependent change, and broader seasonal fluctuations.

Groundwater flow directions and gradients measured for the shallow and deeper aquifers at the FTPs Source Area did not appear to change appreciably during the field activities of 1993 and may indicate a relatively stable hydrologic regime representative of low gradients and few changes in flow direction or gradient.

7.1.3.4 Aquifer Testing

Previous investigations performed at Fort Wainwright have characterized aquifer properties. In general, the aquifer north and south of the Chena River is very transmissive. Because of the high transmissivity and the large volume of potentially contaminated water that would be generated, pump tests were not conducted during RI activities. However, slug tests were performed at the FTPs Source Area to confirm previous estimates from aquifer hydraulic parameters of the underlying aquifer. Because the slug tests provide general aquifer parameter information, specific aquifer performance values have not been obtained. This data gap, however, is not considered critical for the purposes of this RI/FS. Data collected were also compared to the data collected during previous investigations.

The data generated from the slug tests were used to calculate the value of hydraulic conductivity for the immediate area surrounding the well screen. Although the conductivity value determined may have been influenced by skin effects (the screen filter sand and formation smearing by the drilling bit), the value is still a good estimate of the subsurface hydraulic properties.

The computer program GWAP (1987) was used to perform the Cooper *et al.* method (1967), while a Lotus 123 spreadsheet was used to manipulate the data for analysis using the Hvorslev method (1951). A copy of the aquifer testing data is provided in Appendix G.

Horizontal hydraulic conductivities calculated for the slug tests performed at AP-6156 indicate a low-range hydraulic conductivity of approximately 1.1×10^{-3} ft/second (97.7 ft/day) and a high-range hydraulic conductivity of approximately 3.77×10^{-2} ft/second (3,257 ft/day). A low-range value of transmissivity of approximately 35,000 gpd/ft and a high-range value of transmissivity of approximately 1,200,000 gpd/ft were determined from the data, based on a 50-foot saturated thickness. These values are within the ranges for sand and gravel aquifers and are comparable to data generated by other investigations at Fort Wainwright, as discussed in Section 3.

7.1.3.5 Groundwater Travel Time

Darcy velocities were determined only for the shallow aquifer zone underlying the FTPs Source Area. Values were calculated using an assumed effective porosity of 30% for a sand and gravel aquifer and the conductivity determined from slug tests of the shallow aquifer, as well as the differences in head elevation potential between wells AP-6155 and

AP-6147, which were completed in the shallow aquifer. The overall low velocity in the shallow aquifer across the FTPs Source Area was calculated to be approximately 5.86×10^{-6} ft/second (185 ft/year), and the high velocity was calculated to be approximately 2.01×10^{-4} ft/second (6,340 ft/year). The groundwater flow velocities are presented as an estimation of groundwater flow across the FTPs Source Area and may not represent the actual groundwater and contaminant movement processes occurring. Groundwater velocities may vary due to any number of changing factors, including retardation of contaminants such as partitioning, degradation, changes within the flow system such as heterogeneities in the lithology, permafrost, precipitation events, or stage changes in the Chena River but offer an estimation on expected travel times of contaminants.

7.1.3.6 Hydrogeochemistry

Chemical analyses including cation and anion analysis of groundwater was performed at the FTPs Source Area to characterize the chemistry of the underlying aquifer and provide insight into surface water and groundwater interactions and contaminant fate and transport studies. An evaluation of the general groundwater chemistry in the immediate vicinity of the FTPs Source Area for wells AP-6147, AP-6155, and AP-6156 was completed using Stiff and Piper diagrams as a characterization tool (Figure 7-6). Stiff diagrams are used to provide information on areal trends that may exist in an area, while Piper diagrams give an indication of chemical trends that may exist. A general mass balance for the groundwater samples from the monitoring wells was also calculated for the cations and anions determined from laboratory analysis and a hard copy form of the hydrogeochemical data is provided in Appendix D.

In general, groundwater samples submitted for geochemical analysis where the pH is less than 6 and the mass balance of cations to anions is over 5% are considered unusable for evaluation. This is due to the limiting geochemical reactions, including the results being inaccurate, other constituents being present that are not used in the balance, or organic ions are present in significant quantities. Based on analysis, data from all of the FTP wells examined did not meet a cation/anion balance of less than 5%, and an error of around 9% was determined for all of the wells. This may indicate that ions present in the FTPs Source Area may not be accounted for in the balance calculation. The data was evaluated independent of the results of the mass balance.

An examination of the Stiff diagrams indicate that there is no areal difference in water samples collected from upgradient and downgradient locations of the FTPs Source Area. Piper diagrams indicate that there is a chemical trend between shallow and deeper groundwater at the FTPs Source Area. The deeper groundwater at the site shows a more alkaline chemical component than the shallow groundwater and may indicate a stronger mixing influence with the regional groundwater.

A comparison of chemical analyses of the Chena River surface water samples from SD-10 and SD-14 locations and FTPs Source Area wells show that no discernable variations exist between the surface water samples and the groundwater samples. An areal comparison of Stiff diagrams between CSY wells AP-6142, AP-6143, and AP-6141 and FTP wells, both completed in the Chena and Tanana rivers alluvium, indicate that slight similarities exist between the source areas that may be indicative of the alluvial flow system.

7.1.3.7 Turbidity

Turbidity was measured at the time of groundwater sampling but was not used as a criterion for well development as approved in the MP (E & E 1993a). The turbidity values measured at wells across the Fort historically have yielded low to very high turbidity. The sampled values of turbidity and the groundwater sample photographs (see Appendix D) were reviewed for potential turbidity trends geographically.

An areal comparison of turbidity values measured at shallow monitoring wells at the FTPs indicates that higher turbidity values generally exist south-southwest and upgradient of the site. Wells AP-6146 and AP-6147 exceeded 100 NTUs, whereas wells near FTP-3A and FTP-3B were generally less than 50 NTUs. No indications are suggested for this trend because of the variables that can affect turbidity.

7.1.4 Ecology

The ERA (companion document to the RI) contains a thorough review and evaluation of the ecology at the FTPs Source Area. The following description summarizes those findings.

The FTPs Source Area is located in cleared areas surrounded by paper birch and white and black spruce forest. The cleared area associated with FTP-3A is a regularly mowed grass field. The area associated with FTP-B is sparsely vegetated with grasses and shrubs.

The depression north of the access road between the FTPs Source Area is sparsely vegetated with grasses and shrubs and surrounded by the same forest type.

The forested areas provide potential breeding and foraging habitat for birds and mammals. Small burrowing mammals may reside in the grassy areas. A fox was observed on several occasions traveling through the cleared area at FTP-3A.

7.2 NATURE AND EXTENT OF CONTAMINATION

This section summarizes analytical results by media generated during the 1993 and 1994 field seasons at the FTPs Source Area. An overview of the nature of contamination is followed by discussion of extent, or spatial distribution, of contamination. All chemicals detected at the FTPs Source Area are presented in Tables 7-4 to 7-9. A complete listing of the analytical results is provided in Appendix I. Within each media, inorganic results are discussed separately from organic compounds. Within the organic results discussion, field laboratory results are discussed first, followed by petroleum-related compounds, VOCs, and pesticides. All samples collected at the FTPs Source Area were analyzed by the field laboratory. The analytical results were used to make field decisions such as determining where further sampling was needed or locating boreholes or wells. The field analytical results are presented in this section for the sake of completeness, however, they were not used to determine COPCs. To assist in putting the nature and extent of contamination into a human health perspective, each discussion also includes those chemicals considered to be COPCs at the FTPs Source Area. An overview of the procedure for selection COPCs follows.

A conservative risk-based screening procedure was used to select COPCs at the FTPs Source Area. This screening procedure was identical to that used for the OU-4 Baseline Human Health Risk Assessment, which was amended from the screening procedure used in the Approach Document for the Baseline Human Health Risk Assessment (E & E 1994) based on the availability of updated toxicity information and comments received from the Corps, ADEC, and EPA. The Approach Document identifies those compounds that pose a potential risk to human health. The RI builds on this information by providing more detail on the nature and extent of these compounds at each OU-4 source area. The Baseline Human Health Risk Assessment quantitates the risks posed by those compounds and further defines those that potentially pose a substantial risk to the public.

Chemicals detected at the FTPs Source Area were screened against risk-based concentrations for residential soil and drinking water derived from EPA, Region 3, guidance (EPA 1994a). EPA, Region 10, specifies the use of this guidance for screening purposes (EPA 1994d) because it reflects the most current toxicity available criteria. EPA's current action level for lead in drinking water of 15 μ g/L (EPA 1991) and EPA's updated lead in soil screening concentration of 400 mg/kg was also used for this screening process (EPA 1994e).

To be conservative, chemicals detected in surface soil, subsurface soil, and sediment were compared to the risk-based concentration equivalent to a 1×10^{-7} excess cancer risk, or a hazard quotient of 0.1. All chemicals detected in groundwater and surface water were compared to the risk-based concentration equivalent to a 1×10^{-6} excess cancer risk, or a hazard quotient of 0.1. Chemicals exceeding one or both of these criteria were considered to be COPCs. State of Alaska Water Quality Standards (18 AAC 70) and MCLs (18 AAC 80) have been included in the analytical tables only for the sake of comparison because ARARs have not been established for the source area. Table 7-3 lists the risk-based concentrations for analytes detected at the FTPs Source Area.

Because petroleum products do not have RBCs, petroleum contamination in soil was compared to values in the cleanup matrix scoresheet from the *Interim Guidance for Non-UST Contaminated Soil Cleanup Levels*, Guidance No. 001, Revision No. 1, July 17, 1991 (ADEC 1991). DRO and GRO analyses were not conducted for every sample. For those samples that do not have DRO and GRO results, the results of the fuel ID analysis were compared to the matrix values, which would be quantitated analytically in similar ranges. Bunker C-range organics were compared to the value for residual-range petroleum hydrocarbons because, analytically, they would be quantitated within that range. The State of Alaska does not have a specific cleanup level for petroleum in water, but does not allow the presence of a visible sheen, discoloration, film, odor, or taste, according to organoleptic tests. These tests were conducted; therefore, it was assumed that if petroleum hydrocarbons were detected in water, they were COPCs.

Inorganics were eliminated as COPCs if they were present at naturally occurring (i.e., background) concentrations at OU-4. First, concentrations were compared to the Corps-recommended background data for arsenic, barium, cadmium, chromium, and lead in soil and groundwater because these values have been established statistically (Corps 1994) and are presented in Table 3-3. Sample results were then compared to the maximum detected

background concentration in each environmental medium at each source area. Background samples were collected from locations believed to be unaffected by site-related contaminants because of their upgradient locations and distance from known or suspected contamination sources. Inorganics for which Corps-recommended background values and risk-based concentrations were not available were compared to the range of concentrations of these elements in Alaskan soils (Gough 1988).

Aluminum, calcium, iron, magnesium, potassium, and sodium were eliminated from the nature and extent of contamination discussions because they are not associated with toxicity to humans under normal circumstances (EPA 1991, Region 10 guidance). None of these elements were retained as COPCs at the FTPs Source Area. In several instances, the maximum detected concentration of cobalt exceeded background concentrations but not the maximum reported cobalt concentration of 55 mg/kg for Alaskan soil (Gough 1988). Therefore, cobalt was not considered to be a COPC at the FTPs Source Area.

Any chemical existing at concentrations even approaching a potential risk to human health was identified using this conservative screening approach. A more detailed description of the human health risk-based COPC screening procedure is presented in the OU-4 Baseline Human Health Risk Assessment.

Table 7-3 lists the risk-based concentrations and source area-specific background concentrations used for comparison purposes.

7.2.1 Nature of Surface Soil Contamination

Sixty-two surface soil samples were collected from 54 locations at the FTPs Source Area, including two background samples, using sampling techniques described in Section 2. Blind duplicate samples were collected at eight of the 54 locations. All samples were analyzed at the field laboratory for FSPH and FSVOC. FSPH was detected in 13 surface soil samples. The FSPH results ranged from 21 to 93,000 μ g/kg with a mean concentration of 14,800 μ g/kg. A brief summary of FSVOC is provided in Table 7-5. O-xylene was detected in one sample at a concentration of 8.2 μ g/kg. A summary of project laboratory analytical results for surface soil is presented in Table 7-4.

7.2.1.1 Inorganic Contaminants

Antimony was detected in 10 surface soil sample locations at concentrations ranging from an estimated 12 to 25 mg/kg. The background surface soil collected from AP-6147 contained antimony at 14 mg/kg; the sample collected from background location AP-6146 did not contain antimony above the detection limit of 10 mg/kg. A Corps-recommended background value for antimony in soil is unavailable. The risk-based concentration for antimony is 3.1 mg/kg. Samples at four locations contained antimony above the background value. Samples at nine locations exceeded the risk-based concentration.

Arsenic was detected in all surface soil samples at concentrations ranging from 5.0 to 78 mg/kg. Arsenic was detected in the background samples collected from AP-6146 and AP-6147 at 9 and 10 mg/kg, respectively. Thirty samples from 27 locations had arsenic concentrations above the Corps-recommended background value for soil south of the Chena River of 14 mg/kg. The risk-based concentration for arsenic is 0.037 mg/kg. Concentrations in all samples exceeded the risk-based concentration.

Barium was detected in every surface soil sample collected from the FTPs Source Area. Barium concentrations in FTPs Source Area surface soil ranged from 62 to 758 mg/kg. The Corps-recommended background value for barium in soil south of Chena River is 115 mg/kg; the risk-based concentration for barium is 550 mg/kg. The barium concentrations in the background surface soil collected from AP-6147 and AP-6146 were 115 mg/kg and 92 mg/kg, respectively. Samples from 38 locations contained barium at concentrations greater than the Corps-recommended background level. Samples from three locations had barium concentrations exceeding the risk-based concentrations.

Cadmium was detected in 13 surface soil samples at concentrations ranging from 1.0 to 4.0 mg/kg. The background surface soil samples did not contain cadmium at concentrations above the detection limit of 1.0 mg/kg. Eight samples exceeded the Corpsrecommended background concentration for cadmium in soil south of the Chena River of 1.8 mg/kg. One sample exceeded the risk-based concentration for cadmium of 3.9 mg/kg.

Manganese was detected in every surface soil sample collected from the FTPs Source Area. Concentrations ranged from 39 to 456 mg/kg. There is no Corps-recommended background value for manganese in soil in the Fort Wainwright area; the risk-based concentration for manganese is 39 mg/kg. The background surface soil collected from AP-6146 and AP-6147 contained manganese at 344 mg/kg and 395 mg/kg, respectively. All samples

except one exceeded the risk-based concentration. Samples from five locations contained manganese at concentrations greater than the highest background level.

Vanadium was also detected in every surface soil sample collected from the FTPs Source Area. Concentrations ranged from 18 to 61 mg/kg. There is no Corps-recommended background value for vanadium in soil in the Fort Wainwright area. The background surface soil collected from AP-6146 and AP-6147 contained vanadium at 36 mg/kg and 44 mg/kg, respectively. Samples at 15 locations had concentrations in excess of the highest background level. One sample exceeded the risk-based concentration of 55 mg/kg.

Chromium, copper, lead, nickel, and zinc were detected in all surface soil samples at concentrations that exceeded the background concentrations but were less than the respective risk-based concentrations; therefore, these analytes will not be addressed further.

Mercury was detected in one surface soil sample at 0.6 mg/kg, which is less than the risk-based concentration of 2.3 mg/kg. Mercury was not detected in the background samples above the detection limit of 0.2.

Selenium was detected in 18 of the surface soil samples collected at the FTPs Source Area. Concentrations ranged from 1 to 6 mg/kg. Selenium was not detected above the detection limit of 1 mg/kg in the background surface soil collected from AP-6146 and AP-6147. All selenium concentrations detected in surface soil were less than the risk-based concentration of 39 mg/kg. Mercury and selenium are not considered to be COPCs.

Antimony, arsenic, barium, cadmium, manganese, and vanadium were retained as COPCs in surface soil at the FTPs Source Area.

7.2.1.2 Organic Contaminants

Fuel ID analyses indicated the presence of diesel, gasoline, and TRPH in surface soil at the FTPs Source Area. TRPH was detected in 56 samples with a maximum concentration of 15,000 mg/kg at SS-36. Using modified method 8,015 diesel was detected at eight sample locations with a maximum concentration of 2,700 mg/kg at the surface of boring AP-6169. DRO were detected at four locations at concentrations ranging from 45 to 8,100 mg/kg. Gasoline was detected at five out of six locations. With the exception of SS-25, which had a gasoline concentration of 60 mg/kg, the other four locations exhibited concentrations ranging from 11 to 12 mg/kg. Additional surface soil was collected from "hot spot" locations identified during the 1993 field activities in May 1994 (see Table 7-6). In these samples,

GROs were detected in one sample at 1.2 mg/kg. DROs ranged from 12 to 5,690 mg/kg. TRPH values ranged from 118 to 20,500 mg/kg. Levels of TRPH; diesel; DRO; and, in one location, GRO, exceed State of Alaska cleanup matrix level guidelines.

Fifteen surface soil samples from the FTPs Source Area were analyzed for dioxin and furan. The dioxin and furan congeners detected in these samples were 1,2,3,4,6,7,8,9-OCDD; 1,2,3,4,6,7,8,9-OCDF; 1,2,3,4,6,7,8-heptachlorodibenzodioxin (HpCDD); 1,2,3,4,-6,7,8-heptachlorodibenzofuran (HpCDF); 1,2,3,4,7,8-hexachlorodibenzodioxin (HxDD); 1,2,3,6,7,8-HxCDD; and 1,2,3,7,8,9-HxCDD. All congeners except 1,2,3,4,6,7,8-HpCDD were present at concentrations less than the corresponding risk-based concentrations. This congener was detected at 10 surface soil sample locations at concentrations ranging from 1.8 to 45 pg/g.

The compound 4,4'-DDT was detected at 39 surface soil sample locations from 0.01 to 0.67 mg/kg (the duplicate result for this sample was 0.32 mg/kg). Samples from two locations exceeded the risk-based concentration for 4,4'-DDT of 0.19 mg/kg. In the background samples collected from AP-6146 and AP-6147, 4,4'-DDT was detected at concentrations of 0.01 mg/kg and 0.15 mg/kg, respectively. There are no established background values for 4-4'-DDT for the Fort Wainwright area. However, the Corps has conducted a study of background concentrations of 4,4'-DDT, 4,4'-DDD, and 4-4'-DDE at Fort Wainwright. The data from this RI were included in the Corps' report, which is due in draft form in fall 1994.

Of the 15 organic compounds detected at the FTPs Source Area (excluding the dioxin/furan congeners), only five of these (4,4'-DDD; 4,4'-DDE; 4,4'-DDT; acetone; and methylene chloride) were detected in more than 5% of the surface soil samples. Only 4,4'-DDT was detected at concentrations greater than its risk-based concentrations.

Based on the screening criteria, the organic COPCs for surface soil at the FTPs Source Area include TRPH, DRO, GRO, diesel, 4,4'-DDT, and 1,2,3,4,6,7,8-HpCDD.

7.2.2 Nature of Subsurface Soil Contamination

7.2.2.1 Inorganic Contaminants

Area at concentrations exceeding the risk-based concentration. However, only one subsurface soil sample contained arsenic at a concentration greater than the Corps-recommended

background level of 14 mg/kg for soil south of the Chena River. This sample was collected from one background sample location (AP-6146) at 12 feet BGS and contained arsenic at 15 mg/kg. Other arsenic background concentrations obtained during the subsurface soil investigation include: 6 mg/kg from AP-6146 at 22 ft and 7 mg/kg and 2 mg/kg from AP-6147 at 12 ft BGS and 19 feet BGS, respectively. Arsenic was not retained as a COPC for subsurface soil.

Chromium was detected in subsurface soil samples at 7 to 23 mg/kg. Chromium was detected in a duplicate sample at an estimated 44 mg/kg; however, the original sample contained chromium at 9 mg/kg. Chromium concentrations in the background samples collected from AP-6147 were 16 mg/kg at 12 ft BGS and 10 mg/kg at 19 ft BGS. Concentrations of chromium from background location AP-6146 were 24 mg/kg at 12 ft BGS, and 10 mg/kg at 22 ft BGS. Three samples exceeded the Corps-recommended background concentration for chromium in soil south of the Chena River of 19 mg/kg. One sample (i.e., the duplicate sample described above) exceeded the risk-based concentration of 39 mg/kg.

Manganese was detected in subsurface soil samples at 73 to 872 mg/kg. There are no Corps-recommended background concentrations for manganese for Fort Wainwright. The manganese concentrations in the background samples collected from AP-6147 were 252 mg/kg at 12 ft BGS and 147 mg/kg at 19 ft BGS. Manganese concentrations from AP-6146 were 586 mg/kg at 12 ft BGS and 353 mg/kg at 22 ft BGS. Two samples exceeded the highest background concentration (AP-6157,12 ft BGS, 651 mg/kg; AP-6150, 9 ft BGS, 872 mg/kg), and all samples exceeded the risk-based concentration of 39 mg/kg.

Selenium was detected in one subsurface soil sample at 19 feet at 2 mg/kg. Selenium was not detected in background subsurface soil samples. This sample did not exceed the risk-based concentration of 39 mg/kg. Consequently, selenium was not retained a COPC for subsurface soil.

Barium, copper, lead, vanadium, and zinc were detected in every subsurface soil sample collected from the FTPs Source Area; however, none were detected at concentrations above their associated risk-based concentrations. Nickel was detected in greater than 90% of the subsurface soil samples collected from the FTPs Source Area, but also at concentrations less than the established risk-based concentration. All analytes except barium were detected at concentrations less than background. Antimony and cadmium were not detected in subsurface

soil at the FTPs Source Area. Consequently, none of these analytes were retained as COPCs in subsurface soil.

The inorganic COPCs for subsurface soil at the FTP include chromium and manganese.

7.2.2.2 Organic Contaminants

FSPH analyses were conducted on 82 subsurface soil samples. FSPH was detected in 13 surface soil samples from 25 to 2,900 μ g/kg, with a mean concentration of 396 μ g/kg. FSVOC analyses were performed on 75 subsurface soil samples. A summary of the FSVOC analytical results are presented in Table 7-5.

Detected analytes include m&p-xylenes, o-xylene, 1,1-dichloroethene, and trichloroethene.

Project laboratory analyses identified TRPH values ranging from 11 to 3,600 mg/kg. GRO were detected in two out of two samples (AP-6174, 11.5 feet BGS, 5 mg/kg; AP-6175, 6.5 feet BGS, 6 mg/kg). DRO was detected in sample AP-6175 (6.5 feet BGS) at 11 mg/kg. Diesel detected using the fuel ID analyses was present in one out of 43 samples at 12 mg/kg (AP-6150). The level of TRPH exceeds the State of Alaska clean up levels for petroleum contaminated soil.

Fourteen dioxin and furan congeners were detected in subsurface soil samples collected from the FTPs Source Area. The only congeners retained as a COPC in subsurface soil at the FTPs Source Area are 2,3,4,7,8-pentachlorodibenzofuran (PeCDF) and 1,2,3,7,8-PeCDF. 2,3,4,7,8-PeCDF was detected in AP-6173 at a concentration of 2.1 pg/g at 10.5 feet BGS. This sample was a blind duplicate analysis of a sample that did not have a detectable level 2,3,4,7,8-PeCDF. The other location where this compound was detected was AP-6175 at a concentration of 2.2 pg/g at a depth of 9.5 feet BGS. 1,2,3,7,8-PeCDF was detected at AP-6175 (9.5 feet BGS) at 1.7 pg/g. This compound was also detected at AP-6173 (10.5 feet BGS) at an estimated concentration of 1.6 pg/g. The risk-based concentration for 2,3,4,7,8-PeCDF and 1,2,3,7,8-PeCDF is 0.82 pg/g. All other dioxin/furan congeners were detected at levels less than the established risk-based concentrations.

Acetone, 2-butanone, 4,4'-DDE, 4,4'-DDT, 4-methyl-2-pentanone, and methylene chloride were the only other organic compounds detected in the subsurface soil at the FTPs Source Area. All of these compounds were present at concentrations less than risk-based

concentrations. 2(2,4-dichlorophenoxy)Propionic acid (dichloroprop) was detected in one out of 17 subsurface soil samples at a concentration of 0.1 mg/kg. There is no risk-based concentration for this compound.

The organic COPCs retained for subsurface soil at the FTPs Source Area are TRPH, 2,3,4,7,8-PeCDF, and 1,2,3,7,8-PeCDF.

7.2.3 Nature of Sediment Contamination

At the time of the field investigation, no surface water was present in the suspected wetland areas. The drainage ditch on the north side of the FTPs Source Area was also dry. Consequently, surface soil samples were collected from the locations where sediment samples were planned, and are referred to as sediment samples. Sediment samples were collected from 15 locations at the FTPs Source Area; three were upgradient or background samples. One blind duplicate sample was collected. Table 7-7 lists the analytes detected in sediment samples collected at the FTPs Source Area.

7.2.3.1 Inorganic Contaminants

Arsenic was detected in every sediment sample at 6 to 52 mg/kg. The background samples contained arsenic concentrations of 9 to 11 mg/kg. Samples from three locations (SD-7, SD-10, and SD-11) exceeded the maximum background concentration. All samples exceeded the risk-based concentration of 0.037 mg/kg.

Lead concentrations in nine sediment samples exceeded background concentrations. One sediment sample contained lead at concentrations greater than the screening level of 400 mg/kg (SD-9, 424 mg/kg); therefore, lead was included as a COPC for sediments.

Manganese was detected in all of the sediment samples at concentrations ranging from 95 to 471 mg/kg. Samples at three locations (SD-3, SD-5 and SD-7) exceeded the background values. Background sample contained manganese at 369, 394, and 343 mg/kg. The risk-based concentration for manganese is 39 mg/kg; all the samples exceeded this risk-based concentration.

Vanadium was also detected in every sediment sample at concentrations ranging from 18 to 56 mg/kg. The background samples contained vanadium concentrations of 42, 46, and 45 mg/kg. Samples from two locations (SD-10 and SD-7) exceeded the highest background

value. One sample (location SD-10) exceeded the risk-based screening level for vanadium of 55 mg/kg.

Barium, chromium, copper, nickel, and zinc were detected in all the sediment samples collected from the FTPs Source Area, but none were present at levels exceeding the established risk-based concentrations. However, all of these elements did exceed background concentrations. Cadmium was detected at two locations (SD-17 and SD-11), and selenium was detected at two locations (SD-10 and SD-11) at levels that exceeded background concentrations but were less than the established risk-based concentrations. Therefore, none of these elements were retained as COPCs.

Inorganic COPCs retained in FTP sediments include arsenic, lead, manganese, and vanadium.

7.2.3.2 Organic Contaminants

FSPH analyses were performed on the sediment samples. FSPH was found in seven samples at 23 to 34,000 mg/kg with a mean concentration of 5,000 mg/kg. FSVOC analysis was performed on 13 sediment samples. FSVOC were not detected in these samples.

TRPH results ranged from 11 to 52,000 mg/kg (SD-17). Diesel was detected in one sample at 16 mg/kg (SD-7). The highest concentrations of TRPH potentially exceed the State of Alaska cleanup matrix levels.

Two sediment samples (SD-6 and SD-8) were analyzed for dioxin and furans and 10 dioxin and furan congeners were detected. The two congeners that were retained as COPCs are 1,2,3,7,8,9-HxCDD and 2,3,4,7,8-PeCDF. All other congeners were detected at concentrations less than the risk-based concentrations. The congener 1,2,3,7,8,9-HxCDD was detected in both samples at concentrations of 0.43 pg/g (SD-6) and 4.4 pg/g (SD-8). The congener 2,3,4,7,8-PeCDF was detected in one sample (SD-8) at 1.3 pg/g.

Other organic COPCs in the sediments were 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT. The compound 4,4'-DDD was detected at six of the sediment sample locations at concentrations ranging from 0.02 to 1.6 mg/kg. The background sediment sample collected from location SD-1 contained 0.02 mg/kg of 4,4'-DDD; 4,4'-DDD was not detected in the other two background samples. The risk-based concentration for 4,4'-DDD is 0.27 mg/kg. Samples from two locations (SD-8 and SD-9) exceeded the risk-based concentration.

The compound 4,4'-DDE was detected at 12 of the sediment sample locations at concentrations ranging from at 0.01 to 0.5 mg/kg. The background sediment samples all contained 4,4'-DDE at 0.02 mg/kg. The risk-based concentration for 4,4'-DDE is 0.19 mg/kg. One sample (SD-8) contained concentrations of this compound exceeding the risk-based concentration.

The compound 4,4'-DDT was detected at 15 of the sediment sample locations at concentrations ranging from 0.02 to 2.8 mg/kg. The background samples contained concentrations of 4,4'-DDT ranging from 0.05 to 0.16 mg/kg. The risk-based concentration for 4,4'-DDT is 0.19 mg/kg. Samples from the five locations (SD-7, SD-8, SD-9, SD-16, and SD-17) contained 4,4'-DDT concentration exceeding the risk-based concentration.

The compounds 1,2-dichlorobenzene and 1,4-dichlorobenzene were detected in two sediment samples (SD-16 and SD-17). Bis(2-ethylhexyl)phthalate was detected in one sample (SD-4). These analytes were all detected at concentrations less than risk-based concentrations; consequently, they were not retained as COPCs in sediment.

The compounds retained as COPCs in FTP sediments include TRPH, 1,2,3,7,8,9-HxCDD, 2,3,4,7,8-PeCDF, 4,4'-DDT, 4,4'-DDD, and 4,4'-DDE.

7.2.4 Nature of Groundwater Contamination

Table 7-8 lists the analytes detected in groundwater samples from the FTPs.

7.2.4.1 Inorganic Contaminants

Total arsenic was detected in eight groundwater sampling wells at concentrations ranging from 9 to 34 μ g/L. Dissolved arsenic was detected in three of the wells at concentrations ranging from 7 to 13 μ g/L; all detected concentrations of dissolved arsenic were above the risk-based concentration of 0.038 μ g/L, but below the Corps-recommended background value of 20 μ g/L for dissolved arsenic and 72 μ g/L for total arsenic in groundwater. All sample concentrations (both dissolved and total) were below the MCL and water quality criterion of 50 μ g/L.

Total barium concentrations ranged from 70 to 1,250 μ g/L. The maximum detected value exceeds the water quality criterion of 1,000 μ g/L. Dissolved barium concentrations ranged from 60 to 168 μ g/L; all dissolved barium concentrations were below the Corpsrecommended background level of 341 μ g/L for dissolved barium in groundwater at Fort

Wainwright and the risk-based concentration of 260 μ g/L. All barium concentrations (both dissolved and total) were less than the MCL of 2,000 μ g/L.

Fluoride was detected in two of the wells at 300 μ g/L and 800 μ g/L. The risk-based concentration for fluoride is 220 μ g/L. The background sample did not contain fluoride above the detection limit of 200 μ g/L. All detected concentrations of fluoride were less than the primary MCL of 4,000 μ g/L, the State of Alaska secondary MCL of 2,000 μ g/L, and the State of Alaska Water Quality Criterion of 2,400 μ g/L. However, because detected fluoride concentrations exceed background and risk-based concentrations, this analyte was retained as a COPC for groundwater.

Manganese was detected in all groundwater samples collected from the FTPs Source Area. Concentrations ranged from 245 μ g/L to 4,520 μ g/L. There is no Corps-recommended background concentration for manganese in groundwater at Fort Wainwright; however, upgradient wells AP-6146 and AP-6147 contained manganese at 2,750 μ g/L and 2,420 μ g/L, respectively. The risk-based concentration is 18 μ g/L. Because detected manganese concentrations exceeded background levels and the risk-based concentrations, this analyte was retained as a COPC for groundwater.

Dissolved zinc was detected in one groundwater sample at the FTPs Source Area at a concentration of 22 μ g/L. There is no recommended background concentration for zinc in groundwater at Fort Wainwright; upgradient wells AP-6146 and AP-6147 did not contain dissolved zinc above the detection limit of 10 μ g/L. The risk-based concentration is 1,100 μ g/L. The secondary MCL for zinc in groundwater is 5,000 μ g/L, and the water quality criterion is 47 μ g/L. Arsenic, barium, fluoride, and manganese were retained as COPCs in the FTP groundwater.

7.2.4.2 Organic Contaminants

Groundwater samples collected using the Geoprobe™ were analyzed for FSPH and FSVOC. Seven groundwater samples were analyzed for FSPH and FSVOC in the on-site field laboratory. FSPH results ranged from 2.5 mg/L to 22.0 mg/L. FSVOC was not detected.

Results of organics analyses performed by the project laboratory are presented in Table 7-8. Several groundwater samples contained diesel (detected by both modified method

8015 and modified method 8100). Six locations had detectable levels of diesel ranging from $52 \mu g/L$ to 576 $\mu g/L$. Two additional locations contained 400 $\mu g/L$ TRPH.

Benzene and bromodichloromethane were each detected in one of the 13 monitoring wells (benzene and was detected in well AP-6150, and bromodichloromethane was detected in well AP-6156) at concentrations exceeding their respective risk-based concentrations.

The compound 1,2-dichloroethane (1,2-DCA) was detected in four of the 14 monitoring wells at 0.7 to 2.0 μ g/L. Two of the four positive results for 1,2-DCA were in the upgradient wells AP-6146 (2.0 μ g/L) and AP-6147 (1.8 μ g/L). Concentrations of 1,2-DCA in the outer wells were lower, 0.7 μ g/L in AP-6145 and 0.8 μ g/L in AP-6152. The risk-based concentration for 1,2-DCA is 0.12 μ g/L; the MCL is 5 μ g/L.

Chloroform was detected in seven of the 14 wells at 0.6 to 14 μ g/L. Samples collected from upgradient wells AP-6146 and AP-6147 did not contain chloroform. The risk-based concentration for chloroform is 0.15 μ g/L; the MCL is 100 μ g/L.

In 1993, TCE was detected in three monitoring wells (AP-6152, AP-6154, and AP-6157). Concentrations were 19 μ g/L in AP-6152, 1.0 μ g/L in AP-6154 and 0.6 μ g/L in AP-6157. When these three wells were resampled in 1994, TCE was detected only in AP-6152 at 1.2 μ g/L. The MCL for TCE is 5 μ g/L. Table 7-9 presents the 1994 sampling results and compares them to the 1993 results from same wells.

The compounds 1,1,1-trichloroethane, acetone, isopropylbenzene, toluene, and total xylene were also detected in FTP groundwater. However, concentrations were all below risk-based screening concentrations. The compound sec-butylbenzene was detected in one well (AP-6150). No risk-based concentration or MCL is currently available for comparison to the detected result.

Diesel, TRPH, benzene, bromodichloromethane, chloroform, 1,2-dichloroethane, and TCE were retained as COPCs in FTP groundwater.

7.3 EXTENT OF CONTAMINATION AT THE FIRE TRAINING PITS

The sampling objectives for the FTPs Source Area were to determine the nature and extent of contamination associated with the two defined FTPs and to determine the extent of contamination associated with fire training activities at other areas within this source area. Table 7-10 lists the analytes that exceeded background or risk-based concentrations. The

following discussion describes the extent of contamination for each medium at the FTPs Source Area based on data generated for each medium from the 1993 and 1994 field seasons.

7.3.1 Extent of Surface Soil Contamination

Elevated levels of site-related contaminants in surface soil at the FTPs Source Area are mainly associated with FTP-3A and limited areas at FTP-3B and the depression north of the access road. Figures 7-7 through 7-11 present locations where concentrations of contaminants in surface soil are elevated.

Antimony was detected above background levels in two surface soil in the FTP-3A grid and at AP-6148.

Elevated arsenic concentrations were detected mainly in the surface soil sample grid established at FTP-3A. In addition, arsenic was detected above the Corps-recommended background value (14 mg/kg) in one surface soil sample location at FTP-3B (SS-35; see Figures 7-7A and 7-7B).

Barium concentrations in the FTPs Source Area were generally between the Corpsrecommended background value of 115 mg/kg and the risk-based concentration of 550 mg/kg. Three sampling locations contained barium at greater than 550 mg/kg; two in FTP-3A and one in the depression north of the access road.

Cadmium was detected above background in nine locations, eight of which are in the FTP-3A grid (see Figures 7-7A and 7-7B). Cadmium was not detected above the risk-based concentration of 3.9 mg/kg, with the exception of one duplicate sample (4.0 mg/kg).

Manganese and vanadium were detected in all surface soil at the FTPs Source Area. Although their detected concentrations exceeded risk-based concentrations, the elevated levels of these elements is generally attributed to natural occurrence and not associated with present or past practices at the FTPs Source Area (see Figures 7-7A and 7-7B).

TRPH was detected in 56 of 62 surface soil samples, including one of the background samples. The highest concentrations were detected at FTP-3A and FTP-3B, and at the surface of monitoring well AP-6152 along the access road. Six additional surface soil samples were collected at AP-6152 during the 1994 field season to further delineate the TRPH contamination detected in 1993. TRPH concentrations in the six additional samples ranged from 118 to 20,500 mg/kg. Locations where detected concentrations of TRPH exceeded Alaska cleanup levels are shown in Figure 7-8. Table 7-6 summarizes the 1994 petroleum hydrocarbon

results. Diesel and gasoline were detected at concentrations exceeding Alaska cleanup levels at FTP-3A as shown in Figure 7-9.

The compound 4,4'-DDT and its derivatives were found in surface soil throughout the FTPs Source Area, including background locations. The areal extent of these compounds has not been completely defined. The presence of these compounds at most of the locations sampled indicates that the application of 4,4'-DDT was widespread. Locations where concentrations of 4,4'-DDT exceeded the risk-based concentration of 0.19 mg/kg are shown in Figure 7-10. Aerial spraying of DDT for mosquito control was a widespread practice in Fairbanks, on Fort Wainwright, and in the interior Alaska communities for a number of years.

Dioxin and furan congeners were detected in surface soil samples collected in and around FTP-3A and FTP-3B, as well as in the cleared area north of the road connecting the FTPs Source Area, and in the background location for FTP-3A. Only one congener (1,2,3,4,6,7,8-HpCDD) at one location (FTP-3B) exceeded its risk-based concentration as shown in Figure 7-11. The detected dioxin and furan congeners probably originated from the burning of chlorinated organic compounds at the FTPs Source Area. This is substantiated by the absence of dioxin and furans congeners in samples located further away from the FTPs Source Area. The presence of dioxin and furan congeners in the background sample appears to be an outlier and is not consistent with the distribution of dioxin and furan concentrations.

7.3.2 Extent of Subsurface Soil Contamination

Elevated levels of site-related contaminants in subsurface soil at the FTPs Source Area are associated with a limited number of samples at FTP-3A, FTP-3B, and the depression north of the access road.

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Chromium and manganese were detected in all subsurface soil samples collected at the FTPs Source Area. Chromium concentrations at a single sample location (AP-6149, 9 feet BGS) at FTP-3B exceeded the risk-based concentration for this analyte. Manganese concentrations in two samples exceeded the maximum detected background concentration of 586 mg/kg. These samples were collected in the northwest corner of FTP-3A (AP-6157, 12 feet BGS) and the western part of FTP-3B (AP-6150, 9 feet BGS).

Subsurface soil contamination with TRPH was identified at locations AP-6149, AP-6152, and AP-6171. The highest concentration at AP-6149 was 3,600 mg/kg at 9 feet

BGS and at AP-6152 at 4.5 feet BGS at a concentration of 2,600 mg/kg, and at 14 feet BGS at a concentration of 102 mg/kg. At AP-6171, a concentration of 438 mg/kg was detected at 12 feet BGS, and a concentration of 102 mg/kg was detected at a depth of 14.5 feet BGS. The contamination at location AP-6149 may be associated with FTP-3B or may be related to other activities (i.e., military). The contamination at location AP-6152 also is not associated with a known FTP area; however, because this hot-spot is next to the access road, it could be related to activities occurring along the road and unrelated to fire training activities. Location AP-6171 is within FTP-3A, and contamination appears to be the result of residual concentrations of petroleum products from training activities. No other soil samples collected at depth indicated petroleum contamination.

Various dioxin and furan congeners were detected in subsurface soil samples from the FTP-3A area and in one location in the depression north of the access road. Dioxin and furans were detected at a maximum depth of 19.5 feet BGS at FTP-3A in the area of the former drum storage area. Only one furan congener, 1,2,3,7,8-PeCDF, was detected at two locations at concentrations nearer than the risk-based concentration. The locations are AP-6173 (10.5 feet BGS) at FTP-3A and AP-6175 (9.5 feet BGS) at the depressed area north of the access road. These elevated concentrations may have resulted from the burning of chlorinated organic compounds at the FTPs Source Area.

7.3.3 Extent of Sediment Contamination

Elevated levels of site-related contaminants in sediment at the FTPs Source Area are mainly associated with the drainage ditch along the northern part of this source area, the depression north of the access road, and sample locations SD-11 located in a wooded area in the center of this source area. Figures 7-12 through 7-14 present locations where concentrations of contaminants in sediment are elevated.

Arsenic, lead, manganese, and vanadium were detected in all sediment samples collected at the FTPs Source Area. Arsenic and manganese concentrations were within the range of concentrations exceeding the maximum detected background concentration at SD-7, SD-10, and SD-11 (see Figure 7-12). Manganese concentrations exceeded the maximum detected background concentration at SD-3, SD-5, and SD-7. Lead exceeded the screening concentration of 400 mg/kg in one sample collected at SD-9 and vanadium exceeded the risk-based concentration in one sample collected at SD-10.

Most sediment samples contained TRPH at concentrations less than 100 mg/kg. At the depression in the wooded area north of the access road, TRPH and FSPH results were significantly elevated (greater than 10,000 mg/kg). Although there was some staining noted in the area (near SD-16), many of the samples that exhibited elevated concentrations of petroleum hydrocarbon did not emit noticeable odors or appear stained. Conversely, some of these soils were dry, loamy and rich in organic matter. The elevated TRPH and FSPH levels in some of these samples may be due to the natural high organic content of the samples.

The pesticides, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were detected at concentrations exceeding risk-based concentrations in the depression north of the access road (SD-8 and SD-9; see Figure 7-7B). Two dioxin furan congeners (1,2,3,7,8,9-HxCDD and 2,3,4,7,8-PeCDF) were detected at SD-6 and SD-8 at concentrations exceeding risk-based concentrations (see Figure 7-13).

7.3.4 Extent of Groundwater Contamination

Elevated levels of site-related contaminants in groundwater at the FTPs Source Area were detected in 10 out of 13 wells sampled at this source area. Figures 7-15 and 7-16 present the locations where concentrations of contaminants in groundwater are elevated.

Fluoride concentrations exceeded both the background concentration of 100 μ g/L and the risk-based concentration of 220 μ g/L at wells AP-6149 and AP-6156.

Manganese concentrations exceeded the background level of 2,750 μ g/L at two locations shown in Figure 7-14. Manganese was detected in all 13 monitoring wells at levels exceeding the secondary MCL of 50 μ g/L. Elevated levels of manganese in the groundwater is considered to be the result of natural occurrence of manganese in the site soil and not a particular waste source.

Chlorinated compounds were detected downgradient of the FTP-3A area. TCE was detected in two of the shallow wells at FTP-3A but not in the deep well. Bromodichloromethane, chloroform, and 1,2-dichloroethane were also detected in wells in the FTP-3A area. In background wells AP-6146 and AP-6147, 1,2-dichloroethane was detected at concentrations exceeding risk-based concentrations. 1,2-Dichloroethane is a common constituent of leaded gasoline. Background well contamination may be originating from an unknown source southeast and upgradient of the FTPs. Such a source could be a previously undetected source

of a spill location or could originate from another on-base facility, such as the DRMO or Badger Road investigation area (i.e., Arctic Surplus or Clear Creek USTs).

North of the access road (AP-6152), 1,2-dichloroethane, chloroform, and TCE were detected. TCE exceeded the MCL of 5 μ g/L. When resampled in 1994, the TCE concentration in AP-6152 was less than the MCL.

Chloroform was detected in all three wells at FTP-3B. Well AP-6150 also contained benzene at concentrations exceeding the State of Alaska MCL of 5 μ g/L.

Compounds of concern in the groundwater at the FTPs Source Area were present in three areas: FTP-3A, FTP-3B, and AP-6152. Figure 7-15 shows the locations where organic compounds exceed risk-based concentrations.

7.4 CHEMICAL-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO-BE-CONSIDERED CRITERIA

Chemical-specific ARARs/TBCs for the FTPs Source Area are discussed below. Action-specific ARARs will be presented in the OU-4 feasibility study. A preliminary list of chemical-specific ARARs and TBCs was developed during preparation of the OU-4 Management Plan. Many substances identified initially were not detected in the most recent sampling events, and additional substances were detected that had not been identified previously. Tables 7-11 and 7-12 present potential chemical-specific ARARs and TBCs.

No federal chemical-specific ARARs exist for soil; therefore, state standards were used. However, the State of Alaska Oil and Hazardous Substances Pollution Control regulations (189 AAC 75) require that any person discharging a hazardous substance to land or waters must report it immediately to the State. In addition, the discharge must be cleaned up to the department's satisfaction. Eighteen AAC 75 provides the regulatory basis for the cleanup of non-UST related contamination in soil and must be considered a TBC. This guidance states that soil contaminated by hazardous substances, other than crude oil or refined petroleum fuel products must be cleaned to background levels or levels shown through leaching to pose no risk to potential surface receptors. EPA, Region 3, risk-based concentrations are presented as TBC criteria. The risk-based concentrations for soil presented in this RI represent either the risk of one person in 10 million developing cancer over their lifetime for carcinogens, or a hazard quotient of 0.1 for noncarcinogens.

The State of Alaska administers the federally-designated drinking water program; therefore, state MCLs were selected as potential ARARs. In addition, the State of Alaska

Water Quality Standards have been cited as TBCs. These include values from the water quality standards tables and from the State of Alaska Water Quality Standards Workbook (ADEC 1991b). Other requirements to be considered included secondary MCLs and EPA, Region 3, risk-based concentrations (EPA 1994). The risk-based concentrations for groundwater presented in this RI represent either a risk of one person in 1 million developing cancer over their lifetime for carcinogens, or a hazard quotient of 0.1 for noncarcinogens.

Table	7	-1
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FIRE TRAINING PITS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Monitoring Wells	Depth
AP-6145	25
AP-6146	30
AP-6147	29
AP-6148	28
AP-6149	27
AP-6150	30
AP-6151	28
AP-6152	28
AP-6153	28
AP-6154	30
AP-6155	17
AP-6156	100
AP-6157	28
Borings	
AP-6169	17
AP-6170	17
AP-6171	14.5
AP-6172	16
AP-6173	14.5
AP-6174	19.5
AP-6175	12

SUMMARY OF ASTM D-2487 SOIL CLASSIFICATION AND GEOLOGIST'S FIELD CLASSIFICATION FIRE TRAINING PITS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Well No. or Station No.	Sample Number	Depth (ft BGS)	ASTM	Field Classification
SS-10	93FTP039SS	0.5	SM	SM
SS-12	93FTP041SS	0.5	GM	SM/GM
SS-17	93FTP046SS	0.5	SM	SM
AP-6174	93FTP013SB	11.5	SP/SM	SP
AP-6174	93FTP014SB	14.5	SP	SP/GP
AP-6175	93FTP015SB	6.5	SM	SM
AP-6175	93FTP016SB	9.5	SP/SM	SP/SM
AP-6154	93FTP063SS	0.5	SM	SM

Key:

ASTM = American Society for Testing and Materials.

ft BGS = Depth below ground surface in feet.

GM = Silty gravel.

GP = Poorly graded gravel.

SM = Silty sands.

SP = Poorly graded sands.

RISK-BASED CONCENTRATIONS^a FOR ANALYTES DETECTED IN THE FIRE TRAINING PITS REMEDIAL INVESTIGATION OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

	Analytes Detected in So	ils and Sediment		Analytes Detected in Surface and Groundwater				
Analyte	Background Surface Soil	Background Sediment	Risk-Based Concentration (mg/kg) ^b	Analyte	Background Groundwater	Risk-Based Concentration (µg/L) ^c		
Inorganics				Inorganics				
Aluminum	12,100	11,000	N/A	Arsenic	20	0.038		
Antimony	14	5	3.1	Barium	341	260		
Arsenic	14	11	0.037	Calcium	68,900	N/A		
Barium	115	120	550	Chloride	2,900	N/A		
Cadmium	1.8	0.5	3.9	Fluoride	100	220		
Calcium	7,350	8,050	N/A	Iron	44,600	N/A		
Chromium	19	23	39	Magnesium	22,300	N/A		
Cobalt	11	12	N/A	Manganese	2,750	18		
Copper	29	27	290	Potassium	5,700	N/A		
Iron	23,400	23,000	N/A	Silicon	70,100	N/A		
Lead	26	9	400	Sodium	6,740	N/A		
Magnesium	6,860	6,500	N/A	Sulfate	30,000	N/A		
Manganese	395	394	39	Zinc	5	1,100		
Mercury	0.2U	0.2U	2.3	Organics				
Nickel	26	26	160	1,1,1-Trichloroethane		N/A		

RISK-BASED CONCENTRATIONS^a FOR ANALYTES DETECTED IN THE FIRE TRAINING PITS REMEDIAL INVESTIGATION OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

An	alytes Detected in So	ils and Sediment		Analytes Detecte	d in Surface and Gro	oundwater
Analyte	Background Background Concentration (mg/kg) ^b Analyte		Analyte	Background Groundwater	Risk-Based Concentration (µg/L) ^c	
Phosphorus			N/A	1,2-Dichloroethane		0.12
Potassium	994	1,150	N/A	Acetone		370
Selenium	0.1U	0.1U	39	Benzene		0.36
Sodium	455	377	N/A	Bromodichloromethane		0.17
Vanadium	44	46	55	Chloroform		0.15
Zinc	56	58	2,300	Isopropylbenzene		150
Organics				sec-Butylbenzene		N/A
1,2,3,4,6,7,8,9-OCDD			0.000410	Toluene		75
1,2,3,4,6,7,8,9-OCDF			0.000410	Total xylenes		1,200
1,2,3,4,6,7,8-HpCDD			0.000041	Trichloroethene		N/A
1,2,3,4,6,7,8-HpCDF			0.000041			
1,2,3,4,7,8,9-HpCDF			0.000041			
1,2,3,4,7,8-HxCDD			0.0000041			
1,2,3,4,7,8-HxCDF			0.0000041			
1,2,3,6,7,8-HxCDD			0.0000041			
1,2,3,6,7,8-HxCDF			0.0000041			

RISK-BASED CONCENTRATIONS^a FOR ANALYTES DETECTED IN THE FIRE TRAINING PITS REMEDIAL INVESTIGATION OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Aı	nalytes Detected in So	ils and Sediment		Analytes Detected	d in Surface and Gr	oundwater
Analyte	Background Surface Soil	Background Sediment	Risk-Based Concentration (mg/kg) ^b	Analyte	Background Groundwater	Risk-Based Concentration (μg/L) ^c
1,2,3,7,8,9-HxCDD			0.0000041			
1,2,3,7,8,9-HxCDF			0.0000041			
1,2,3,7,8-PeCDF			0.0000082			
2,3,4,6,7,8-HxCDF			0.0000041			
2,3,4,7,8-PeCDF			0.00000082			
2,3,7,8-TCDF			0.0000041			
1,2-Dichlorobenzene			700			
1,4-Dichlorobenzene			2.7			
2,4-D			78			
2-Butanone			4,700			
2-Hexanone			N/A			
4,4'-DDD			0.27			
4,4'-DDE			0.19			
4,4'-DDT			0.19			
4-Methyl-2-pentanone			390			
Acetone			780			

RISK-BASED CONCENTRATIONS^a FOR ANALYTES DETECTED IN THE FIRE TRAINING PITS REMEDIAL INVESTIGATION OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

	Analytes Detected in So	ils and Sediment	Analytes Detected in Surface and Groundwater				
Analyte	Background Surface Soil	Background Sediment	Risk-Based Concentration (mg/kg) ^b	Analyte	Background Groundwater	Risk-Based Concentration (μg/L) ^c	
Dichloroprop			N/A				
Methylene Chloride			8.5				
Naphthalene			N/A				
Toluene			1,600				
Total xylenes			16,000				

^a United States Environmental Protection Agency, Risk-Based Concentration Table, Third Quarter 1994, July 11, 1994.

Key:

N/A = Not available.

 $\mu g/L$ = Micrograms per liter.

mg/kg = Milligrams per kilogram.

U =

19:JZ5901_S050-T72-06/22/95-D1

b The risk-based concentrations for soil and sediment corresponding to a cancer risk of 1 ×10⁻⁷ or a hazard quotient of 0.1. These values were derived assuming a residential soil ingestion scenario.

^C The risk-based concentrations for groundwater corresponding to a cancer risk of 1 × 10⁻⁶ or a hazard quotient of 0.1. These values were derived assuming a domestic water use scenario.

SUMMARY OF SURFACE AND SUBSURFACE SOIL RESULTS FIRE TRAINING PITS, OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

		Surface Soil							Subsurface Soil			
Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Conc.	Location of Maximum Conc.	Mean Conc.	Risk- based Conc. ^a	Back- ground Conc. ^b	No. of Samples Analyzed/ Detected	Range of Detected Conc.	Location of Maximum Conc. (ft/bgs)	Mean Conc. ^a	Risk- based Conc. ^a	Back- ground Conc. ^b
Inorganics (mg/kg)												
Aluminum	62/62	1,930-13,400	SS-8	8,850	_	12,100	43/43	3,200-12,000	AP-6146 12'	5,550	_	12,200
Antimony	62/10	12-25	SS-16	15.7	3.1	14	43/0	_	_	_	3.1	10U
Arsenic	62/62	5-78	SS-16	19.7	0.037	14 ^c	43/43	2-15	AP-6146 12'	4.51	0.037	14 ^c
Barium	62/62	62-758	SS-22	218	550	115 ^c	43/43	38-137	AP-6146 12'	61.9	550	115 ^c
Cadmium	62/13	1-4	SS-17	2.1	3.9	1.8 ^c	43/0	_	_	_	3.9	1.8 ^c
Calcium	62/62	1,020-18,800	SS-8	6,110	_	7,350	43/43	1,540-7,060	AP-6145 7'	3,400		6,500
Chromium	62/62	5-25	SS-9	16.9	39	19 ^c	43/43	7-44	AP-6149 9'	12.5	39	19 ^c
Cobalt	62/62	4-13	SS-8/SS-9	9.6		11	43/43	4-14	AP-6146 12'	6.05		14
Copper	62/62	12-72	SS-16	33	290	29	43/43	8-40	AP-6146 12'	13.9	290	40
Iron	62/62	9,950-26,600	SS-9	19,500		23,400	43/43	6,650-26,000	AP-6146 12'	11,600		26,000
Lead	62/62	6-198	AP-6152	19.7	400	26 ^c	43/43	2-12	AP-6152 4.5'	4.44	400	26 ^c
Magnesium	62/62	280-7,260	SS-9	4,937	_	6.860	43/43	2,030-7,270	AP-6146 12'	3,600		7,270
Manganese	62/62	39-456	SS-9	302	39	395	43/43	73-872	AP-6150 9'	240	39	586
Mercury	62/1	0.6	SS-17		2.3	0.2U	43/0		_	_	2.3	0.2U
Nickel	62/62	12-69	SS-17	28.6	160	26	43/40	10-32	AP-6146 12'	14.7	160	32

SUMMARY OF SURFACE AND SUBSURFACE SOIL RESULTS FIRE TRAINING PITS, OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

			<u> </u>		***************************************							
			Surface Soil				Subsurface Soil					
Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Conc.	Location of Maximum Conc.	Mean Conc.	Risk- based Conc. ^a	Back- ground Conc.b	No. of Samples Analyzed/ Detected	Range of Detected Conc.	Location of Maximum Conc. (ft/bgs)	Mean Conc. ^a	Risk- based Conc. ^a	Back- ground Conc. ^b
Phosphorus (total)	5/5	330-430	SS-12	372		_	4/0	_	-		_	
Potassium	62/62	408-1,510	SS-13	980	_	994	43/41	416-1,280	AP-6146 12'	617	_	1,280
Selenium	62/18	1-6	SS-35	2.1	39	0.1U	43/1	2	AP-6154 19'	_	39	1U
Sodium	62/61	63-474	SS-27	312	_	455	43/43	103-464	AP-6146 12'	211		464
Vanadium	62/62	18-61	AP-6154	38.6	55	44	43/43	12-42	AP-6146 12'	22.6	55	42
Zinc	62/62	30-527	SS-16	122	2,300	56	43/43	18-67	AP-6146 12'	29	2,300	67
Organics (pg/g)												
1,2,3,4,6,7,8,9-OCDD	15/14	4.8-240	SS-35	43	410	NA	19/10	1.4-9.8	AP-6173 10.5'	3.8	410	NA
1,2,3,4,6,7,8,9-OCDF	15/3	2.3-3.2	SS-35	2.6	410	NA	19/2	3.7-4.4	AP-6175 9.5'	4.1	410	NA
1,2,3,4,6,7,8-HpCDD	15/11	1.8-45	SS-35	9.4	41	NA	19/4	0.31-3.1	AP-6175 9.5'	1.8	41	NA
1,2,3,4,6,7,8-HpCDF	15/4	0.85-3.9	SS-35	1.7	41	NA	19/7	0.47-11	AP-6175 9.5'	3.1	41	NA
1,2,3,4,7,8-HxCDD	15/1	0.85	SS-35	_	4.1	NA	19/1	0.65	AP-6175 9.5'	_	4.1	NA
1,2,3,6,7,8-HxCDD	15/1	1.9	SS-35		4.1	NA	19/1	1.0	AP-6175 9.5'	_	4.1	NA
1,2,3,7,8,9-HxCDD	15/1	2.1	SS-35		4.1	NA	19/0	_	_	_	4.1	NA
1,2,3,4,7,8,9-HpCDF	15/0	_	_	_	41	NA	19/2	1.4-1.9	AP-6175 9.5'	1.7	41	NA
1,2,3,4,7,8-HxCDF	15/0	_	_	_	4.1	NA	19/2	4.2-5.6	AP-6175 9.5'	4.9	4.1	NA

SUMMARY OF SURFACE AND SUBSURFACE SOIL RESULTS FIRE TRAINING PITS, OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

	Surface Soil								Subsurface Soil			
Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Conc.	Location of Maximum Conc.	Mean Conc.	Risk- based Conc. ^a	Back- ground Conc.b	No. of Samples Analyzed/ Detected	Range of Detected Conc.	Location of Maximum Conc. (ft/bgs)	Mean Conc. ^a	Risk- based Conc. ^a	Back- ground Conc. ^b
1,2,3,6,7,8-HxCDF	15/0	-	_	_	4.1	NA	19/3	0.29-3.4	AP-6173 10.5'	2.0	4.1	NA
1,2,3,7,8,9-HxCDF	15/0	-	_	_	4.1	NA	19/2	0.66-0.81	AP-6175 9.5'	0.74	4.1	NA
1,2,3,7,8-PeCDF	15/0	-	_		8.2	NA	19/2	1.6-1.7	AP-6175 9.5'	1.65	8.2	NA
2,3,4,6,7,8-HxCDF	15/0	_	-	_	4.1	NA	19/3	0.45-2.6	AP-6175 9.5'	1.7	4.1	NA
2,3,4,7,8-PeCDF	15/0	_	_	_	0.82	NA	19/2	2.1-2.2	AP-6175 9.5'	2.15	0.82	NA
2,3,7,8-TCDF	15/0		-	_	4.1	NA	19/2	0.45-0.64	AP-6173 10.5'	0.55	4.1	NA
Organics (mg/kg)												
2,4-D	62/1	1.3	SS-33	_	78	NA	33/0	-			78	NA
2-Butanone	62/1	0.02	SS-5	_	4,700	NA	43/5	0.014-0.024	AP-6175 9.5'	.019	4,700	NA
2-Hexanone	62/2	0.014-0.027	SS-5	.0205	_	NA	43/0	_		_	_	NA
4,4'-DDD	54/6	0.01-0.07	SS-8	0.035	0.27	NA	40/0	_		_	0.27	NA
4,4'-DDE	54/26	0.01-0.18	SS-6	.043	0.19	NA	40/2	0.02-0.04	AP-6147 12'	0.03	0.19	NA
4,4'-DDT	51/43	0.01-0.67	SS-6	.108	0.19	NA	40/6	0.01-0.06	AP-6147 12'	.027	0.19	NA
4-Methyl-2-pentanone	64/2	0.33-0.11	SS-5	.0715	390	NA	22/1	0.25	AP-6148 9'	_	390	NA
Acetone	62/12	0.055-5.4	SS-10	0.656	780	NA	42/24	0.001-55	AP-6156 22'	4.2	780	NA
Methylene Chloride	62/24	0.014 - 0.15	SS-21	0.048	8.5	NA	43/7	0.011-0.11	AP-6151 15'	0.037	8.5	NA

SUMMARY OF SURFACE AND SUBSURFACE SOIL RESULTS FIRE TRAINING PITS, OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

	Surface Soil							Subsurface Soil				
Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Conc.	Location of Maximum Conc.	Mean Conc.	Risk- based Conc. ^a	Back- ground Conc.b	No. of Samples Analyzed/ Detected	Range of Detected Conc.	Location of Maximum Conc. (ft/bgs)	Mean Conc. ^a	Risk- based Conc. ^a	Back- ground Conc. ^b
Naphthalene	62/1	0.022	AP-6148	_		NA	22/0	0.025	_	_	_	NA
Toluene	62/1	0.009	SS-36	_	1,600	NA	22/0	0.001-55			1,600	NA
Total Xylenes	62/1	0.01	SS-35	_	16,000	NA	22/0	_	_		16,000	NA
Dichloroprop	56/0	_	_	_		NA	17/1	0.1	AP-6149 9'		_	NA
Fuels (mg/kg)												
TRPH	62/56	14-15,000	SS-36	1,180	_	NA	43/14	11-3,600	AP-6149 9'	560		NA
Diesel	62/10	10-2,700	AP-6169	690		NA	43/1	12	AP-6150	_	_	NA
DRO	8/5	17-8,100	AP-6169	1,660	_	NA	2/1	11	AP-6175 6.5'			NA
GRO	5/2	6-23	AP-6169	14.5	_	NA	2/2	5-6	AP-6175 6.5	5.5	_	NA
Gasoline	6/5	11-60	SS-25	21.2	_	NA	22/0				_	NA
Other												
TOC (%)	62/62	0.13-2.87	AP-6169	1.28	_	NA	43/41	0.06-1.11	AP-6147 12'	0.213	_	NA

NOTE: Highlighted areas indicate the comparison criteria used to determine whether analyte was a chemical of potential concern.

with the second

a United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 1 × 10⁻⁷. Hazard quotient = 0.1.

b Surface and subsurface soil background data from sample locations AP-6146 and AP-6147, unless otherwise noted.

^C Surface and subsurface soil background data provided by the Corps (1994).

Key:

- = Not available.

DRO = Diesel-range organics.

ft/BGS = Depth below ground surface in feet.

GRO = Gasoline-range organics.

mg/kg = Milligrams per kilogram.

pg/g = Picograms per gram. TOC = Total organic carbon.

U =

FSVOC RESULTS FIRE TRAINING PITS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Matrix	Analyte	Number of Samples Analyzed/Detected	Range (µg/kg)	Mean (μg/kg)	Risk-based Concentration ^a
Surface soil	o-Xylene	62/1	8.2		16,000,000
Subsurface soil	m & p-Xylenes	75/3	5.2-30.5	14.0	16,000,000
	o-Xylene	75/4	7.0-54.8	19.2	16,000,000
	1,1-DCE	75/12	11-70	38.3	110
	TCE	75/1	6.7	_	_

^a United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 1×10^{-7} . Hazard quotient = 0.1.

Key:

m & p-Xylenes = meta-Xylene and para-Xylene.

 $\mu g/kg = Micrograms per kilogram.$

o-Xylene = ortho-Xylene.

1,1-DCE = 1,1-Dichloroethene.

TCE = Trichloroethene.

PETROLEUM HYDROCARBONS IN SOILS FIRE TRAINING PITS

(mg/kg, dry weight) MAY 1994 OPERABLE UNIT 4

FORT WAINWRIGHT, ALASKA

Sample Number	Gasoline-Range Organics	Diesel-Range Organics	Total Recoverable Petroleum Hydrocarbons
94FTP001SS	1.1 U	982	6,290
94FTP002SS	1.2	3,950	16,200
94FTP003SS	1.1 U	5,640	20,500
94FTP004SS	1.2 U	248	1,770
94FTP005SS	1.2 U	12	169
94FTP006SS	1.2 U	37	118
94FTP007SS	1.2 U	38	153

Key:

mg/kg = Milligrams per kilogram.

U = The analyte was not detected at or above detection limits.

Table 7-7

SUMMARY OF SEDIMENT SAMPLE RESULTS FIRE TRAINING PITS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

	-,					
Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Concentrations	Location of Maximum Conc.	Mean Conc. ^a	Risk-based Conc. ^a	Background Conc.b
Inorganics (mg/kg)						
Aluminum	18/18	3,690-12,400	SD-7	9,430		11,000
Arsenic	18/18	6-52	SD-11	12.2	0.037	11
Barium	18/18	91-361	SD-10	156	550	120
Cadmium	18/2	1-2	SD-17	1.5	3.9	0.5
Calcium	18/18	2,120-11,200	SD-3	5,302	_	8,050
Chromium	18/18	9-26	SD-7	19	39	23
Cobalt	18/18	4-13	SD-7	9.5	_	12
Copper	18/18	13-36	SD-10	27.6	290	27
Iron	18/18	10,300-25,200	SD-7	19,240		23,000
Lead	18/18	6-424	SD-9	46.4	400	9
Magnesium	18/18	1,810-6,680	SD-3	5,333	_	6,500
Manganese	18/18	95-471	SD-7	312	39	394
Nickel	18/18	15-27	SD-7	22.3	160	26
Potassium	18/18	493-1,420	SD-7	1,006	_	1,150
Selenium	18/2	4-9	SD-10	6.5	39	0.5
Sodium	18/18	108-459	SD-8	329	-	377
Vanadium	18/18	18-56	SD-10	40.4	55	46
Zinc	18/18	50-133	SD-11	69.4	2,300	58
Dioxins/Furans (pg/g)						
1,2,3,4,6,7,8,9-OCDD	2/2	75-98	SD-6	86.5	410	NA
1,2,3,4,6,7,8,9-OCDF	2/1	1.4	SD-8	_	410	NA
1,2,3,4,6,7,8-HpCDD	2/2	17-34	SD-8	25.5	.41	NA
1,2,3,4,6,7,8-HpCDF	2/2	2-3.3	SD-8	2.7	41	NA
1,2,3,4,7,8-HxCDD	2/1	2	SD-8	_	4.1	NA
1,2,3,6,7,8-HxCDD	2/2	0.92-3.2	SD-8	2.1	4.1	NA
1,2,3,6,7,8-HxCDF	2/1	0.95	SD-8	_	4.1	NA
1,2,3,7,8,9-HxCDD	2/2	0.43-4.4	SD-8	2.4	4.1	NA

Key at end of table.

SUMMARY OF SEDIMENT SAMPLE RESULTS FIRE TRAINING PITS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Concentrations	Location of Maximum Conc.	Mean Conc. ^a	Risk-based Conc. ^a	Background Conc. ^b
2,3,4,6,7,8-HxCDF	2/1	1.2	SD-8	_	4.1	NA
2,3,4,7,8-PeCDF	2/1	1.3	SD-8		0.82	NA
Organics (mg/kg)						
4,4'-DDD	18/6	0.02-1.6	SD-9	0.38	0.27	NA
4,4'-DDE	18/13	0.01-0.5	SD-8	0.088	0.19	NA
4,4'-DDT	18/16	0.02-2.8	SD-8	0.41	0.19	NA
1,2-Dichlorobenzene	18/2	0.007-0.008	SD-17	0.0075	700	NA
1,4-Dichlorobenzene	18/2	0.006-0.007	SD-17	0.0065	2.7	NA
bis(2-Ethylhexyl)phthalate	18/1	0.4	SD-4	_	4.6	NA
Fuels (mg/kg)						
ТПРН	18/14	11-52,000	SD-17	7,702	_	NA
Diesel No. 2	18/1	16	SD-7	_	_	NA
TOC (percent)	18/18	0.39-5.57	SD-17	1.52	_	NA

a Rounded mean of detected concentrations.

Key:

- = Not analyzed.

Conc. = Concentration.

mg/kg = Milligrams per kilogram.

NA = Not applicable.

pg/g = Picograms per gram.

TOC = Total organic carbon.

TRPH = Total recoverable petroleum hydrocarbons.

b Sediment background data from sample lcoations SD-1, SD-2, and SD-15.

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Table 7-8

SUMMARY OF GROUNDWATER RESULTS FIRE TRAINING PITS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Concentrations	Location of Maximum Conc.	Mean Conc. ^a	Risk- based Conc. ^a	Quali	ka Water ty Criteria/ MCL	Back- ground Conc. ^b
Inorganics (Total) (μg/L	.)			,				
Arsenic	14/9	9-34	AP-6146	16	0.038	50	50	72 ^c
Barium	14/14	70-1,250	AP-6145	306	260	1,000	2,000	988 ^c
Calcium	14/14	40,000-118,000	AP-6145	73,550	_			68,900
Chloride	14/13	2,100-6,000	AP-6156	3,140		_	250,000(s)	2,900 ^d
Fluoride	14/2	300-800	AP-6156	550	220	2,400	4,000	200U ^d
Iron	14/14	2,250-123,000	AP-6145	27,080		1,000	300(s)	44,600
Magnesium	14/14	10,200-61,000	AP-6145	22,120				22,300
Manganese	14/14	245-4,520	AP-6155	1,800	18	-	50(s)	2,750
Potassium	14/13	3,990-13,300	AP-6145	5,890	_			5,700
Silicon	14/14	23,900-170,000	AP-6145	52,500	_	_	_	70,100
Sodium	14/14	5,480-37,800	AP-6156	9,380	_	_	-	6,740
Sulfate	14/13	8,300-71,000	AP-6151	35,550		_	250,000(s)	30,000 d
Zinc	14/14	15-407	AP-6145	87.4	1,100	47	5,000(s)	175
Inorganics (Dissolved) μ	g/L		-					
Arsenic	14/4	7-13	AP-6151	10.3	0.038	50	50	20 ^c
Barium	14/14	60-168	AP-6151	117	260	1,000	2,000	341 ^c
Zinc	14/1	22	AP-6152		1,100	47	5,000(s)	10U
Organics (µg/L)								
1,1,1-Trichloroethane	14/1	0.9	AP-6155	_	_	200	200	NA
1,2-Dichloroethane	14/4	0.7-2.0	AP-6146	1.3	0.12	5	5	NA
Acetone	14/4	8-34	AP-6148	21	370			NA
Benzene	14/1	1.1	AP-6150	_	0.36	5 ^f	5	NA
Bromodichloromethane	14/1	1.4	AP-6156	_	0.17	100 ^e	100	NA
Chloroform	14/7	0.6-14	AP-6156	4.3	0.15	1,240	100	NA
Isopropylbenzene	14/1	5	AP-6150	_	150	_	_	NA

Key at end of table.

SUMMARY OF GROUNDWATER RESULTS FIRE TRAINING PITS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Analyte and Concentration Units	No. of Samples Analyzed/ Detected	Range of Detected Concentrations	Location of Maximum Conc.	Mean Conc. ^a	Risk- based Conc. ^a	Qualit	ka Water y Criteria/ MCL	Back- ground Conc. ^b
Sec-butylbenzene	14/1	7	AP-6150	_	_	-	-	NA
Toluene	14/2	0.6-1.4	AP-6153	1.0	75	10 ^f	1,000	NA
Total Xylenes	14/1	2	AP-6153	_	1,200	10 ^f	10,000	NA
Trichloroethene	14/3	0.6-19	AP-6152	6.9	_	5	5	NA
Total recoverable petroleum hydrocarbon	14/2	400-400	AP-6133/ AP-6156	400	_	_	_	NA
Diesel-range organics	2/1	69-72	AP-6151	70.5	_	-		NA
Diesel	11/7	52-576	AP-6150	176	_			NA

NOTE: Highlighted areas indicate the comparison criteria used to determine whether analyte was a chemical of potential concern.

Key:

- = Not analyzed.

BTEX = Benzene, toluene, ethylbenzene, and total xylenes.

Conc. = Concentration.

 $\mu g/L$ = Micrograms per liter.

MCL = Maximum contaminant level.

NA = Not applicable.

(s) = Secondary MCL.

U =

^a United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 1×10^{-7} . Hazard quotient = 0.1.

b Background data from sample locations AP-6146 and AP-6147, unless otherwise noted.

^C Background data provided by the Corps (1994).

d Background data from sample location AP-6147 only.

e Value for total trihalomethanes.

f Value for total BTEX is 10 μ g/L.

COMPARISION OF 1993 AND 1994 VOLATILE ORGANIC COMPOUND RESULTS FIRE TRAINING PITS

 $(\mu g/L)$

OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Compound	Well Number	1993	1994	Risk-based Concentration ^a
1,2-Dichloroethane	AP-6152	0.8	1.1 (duplicate 1.3)	0.12
Trichloroethene	AP-6152	19.0	1.2	5 ^b
	AP-6154	1.0	ND	5 ^b
	AP-6157	0.6	ND	5 ^b

NOTE: Highlighted areas indicate the comparison criteria used to determine whether analyte was a chemical of potential concern.

b MCL.

Key:

 $\mu g/L$ = Micrograms per liter.

MCL = Maximum contaminant level.

ND = Not detected.

^a United States Environmental Protection Agency, Region 3, Risk-based Concentration Table, Fourth Quarter 1994, November 1994. Cancer risk = 1×10^{-7} . Hazard quotient = 0.1.

Table 7-10

ANALYTES EXCEEDING BACKGROUND RISK-BASED CONCENTRATIONS FIRE TRAINING PITS OPERABLE UNIT 4 FORT WAINWRIGHT, LSK

		Exceeds Risk-Based Concentration
Analyte	Exceeds Background ^a	and Background ^b
Inorganics		
Aluminum	SS, SD	
Antimony	SS	SS
Arsenic	SS, SD, GW, SB	SS, SD, GW, SB
Barium	SS, SB, SD, GW	SS, GW
Cadmium	SS, SD	SS
Chromium	SS, SB, SD	SB
Cobalt	SS, SD, SB	
Copper	SS, SD, SB	
Fluoride	GW	GW
Lead	SS, SD	SD
Magnesium	SS, SD, SB, GW	
Manganese	SS, SB, SD, GW	SS, SB, SD, GW
Mercury	SS	
Nickel	SS, SD, SB	
Selenium	SS, SB, SD	
Vanadium	SS, SD	SS, SD
Zinc	SS, SD, GW, SB	
Organics		
1,2,3,4,6,7,8,9-OCDD	SS, SD, SB	
1,2,3,4,6,7,8,9-OCDF	SS, SD, SB	
1,2,3,4,6,7,8-HpCDD	SS, SD, SB	SS
1,2,3,4,6,7,8-HpCDF	SS, SD, SB	
1,2,3,4,7,8-HxCDD	SS, SD, SB	
1,2,3,4,7,8-HxCDF	SB	

Key at end of table.

Table 7-10

ANALYTES EXCEEDING BACKGROUND RISK-BASED CONCENTRATIONS FIRE TRAINING PITS OPERABLE UNIT 4 FORT WAINWRIGHT, LSK

		Exceeds Risk-Based Concentration
Analyte	Exceeds Background ^a	and Background ^b
1,2,3,4,7,8,9-HpCDF	SB	
1,2,3,6,7,8-HxCDD	SS, SD, SB	
1,2,3,6,7,8-HxCDF	SD, SB	
1,2,3,7,8-PeCDF	SB	SB
1,2,3,7,8,9-HxCDD	SS, SD	SD
1,2,3,7,8,9-HxCDF	SB	
2,3,4,6,8-HxCDF	SD, SB	
2,3,4,7,8-PeCDF	SD, SB	SD, SB
2,3,7,8-TCDF	SB	
1,2-Dichloroethane	GW	GW
1,2-Dichlorobenzene	SD	
1,4-Dichlorobenzene	SD	
2-Butanone	SS, SB	
2-Hexanone	SS	
2,4-D	SS	
4-Methyl-2-pentanone	SS, SB	
4,4'-DDD	SS, SD	SD
4,4'-DDE	SS, SD, SB	SD
4,4'-DDT	SS, SB, SD	SS, SD
Acetone	SS, SB, GW	
Benzene	GW	GW
bis(2-ethylhexyl)phthalate	SD	
Bromodichloromethane	GW	GW
Chloroform	GW	GW
Dichloroprop (2-(2,4-Dichlorophenoxy)propionic acid	SB	

Key at end of table.

ANALYTES EXCEEDING BACKGROUND RISK-BASED CONCENTRATIONS FIRE TRAINING PITS OPERABLE UNIT 4 FORT WAINWRIGHT, LSK

Analyte	Exceeds Background ^a	Exceeds Risk-Based Concentration and Background ^b
Diesel	SS, SB, SD, GW	SS, GW
Diesel-range organics	SS, SB, GW	SS
Gasoline	SS	SS
Gasoline-range organics	SS, SB	SS
Methylene chloride	SS, SB	
Naphthalene	SS	
Sec-Butylbenzene	GW	GW
Toluene	SS, GW	
Trichloroethene	GW	GW
Total recoverable petroleum hydrocarbon	SS, SB, SD, GW	SS, SB, SD, GW
Total Xylenes	SS, GW	

^a If organic compounds were detected, they were assumed to exceed background concentrations.

Key:

GW = Groundwater.

N = Risk-based concentration is not available.

SB = Subsurface soil.

SD = Sediment.

SS = Surface soil.

b Petroleum contaminated soils were compared to the Alaska Department of Environmental Conservation cleanup matrix scoresheet.

POTENTIAL CHEMICAL-SPECIFIC ARARS AND TBCS FOR GROUNDWATER FIRE TRAINING PITS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

 $(\mu g/L)$

Constituent	ARARs/State ^a	TBCs
Petroleum hydrocarbons	_	No visible sheen, film, or discoloration. Failure of organoleptic test.
Arsenic	50	0.038/1,000
Barium	2,000	0.260/50 ^e
1,2-Dichloroethane	5	5 ^e
Benzene	.05	10 ^f
Bromodichloromethane	100 ^d	100 ^g
Chloroform	100 ^d	1,240 ^e
Fluoride	4,000	2,400 ^e
Manganese	50 ^b	18 ^c
sec-Butylbenzene	_	
Trichloroethene	5	5

a 18 AAC 80.070(a) Maximum Contaminant Levels.

Key:

ARARs = Applicable or relevant and appropriate requirements.

BTEX = Benzene, toluene, ethylbenzene, and total xylenes.

EPA = United States Environmental Protection Agency.

 $\mu g/L = Micrograms per liter.$

mg/L = Milligrams per liter.

TBCs = To-be-considered criteria.

b 18 AAC 80.070(b) Secondary Maximum Contaminant Levels.

^C Risk-based concentrations equivalent to a cancer risk of 1 × 10⁻⁶ or a hazard quotient of 0.1 (EPA 1994).

d This number applies to total trihalomethanes (the sum of the concentrations of bromodichloromethane, dibromochloromethane, tribromomethane, and chloroform).

e State of Alaska Water Quality Standards Workbook.

f 18 AAC 70 value for BTEX is 10 μ g/L.

g State of Alaska Water Quality Standards Workbook value for total trihalomethanes.

POTENTIAL CHEMICAL-SPECIFIC ARARS AND TBC FOR SOIL FIRE TRAINING PITS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Constituent	TBCs
Antimony	(1) Background or contaminant leaching assessment (2) 3.1 mg/kg
Arsenic	(1) Background or contaminant leaching assessment (2) 0.037 mg/kg
Barium	(1) Background or contaminant leaching assessment (2) 550 mg/kg
Cadmium	(1) Background or contaminant leaching assessment (2) 3.9 mg/kg
Chromium	(1) Background or contaminant leaching assessment (2) 39 mg/kg
Dioxin (2,3,4,8-TCDD)	(1) Background or contaminant leaching assessment (2) 4.1 × 10 ⁻⁷ mg/kg ^b
Manganese	(1) Background or contaminant leaching assessment (2) 39 mg/kg
Vanadium	(1) Background or contaminant leaching assessment (2) 55 mg/kg
4,4'-DDT	(1) Background or contaminant leaching assessment (2) 19 mg/kg
4,4-DDD	(1) Background or contaminant leaching assessment (2) 0.27 mg/kg
4,4-DDE	(1) Background or contaminant leaching assessment (2) 0.19 mg/kg
2,3,4,7,8-PeCDF	(1) Background or contaminant leaching assessment (2) 0.86 mg/kg
2,3,4,7,8-HpCDD	(1) Background or contaminant leaching assessment (2) 43 mg/kg
1,2,3,7,8,9-HpCDD	(1) Background or contaminant leaching assessment (2) 4.3 mg/kg
Diesel-range organics	(1) 100-2,000 mg/kg
Gasoline-range organics	(1) 50-1,000 mg/kg
Residual range petroleum hydrocarbons	(1) 2,000 mg/kg

⁽¹⁾ Interim Guidance for NonUST Contaminated Soil Cleanup Levels, July 17, 1991. "Soils contaminated by hazardous substances other than crude oil or refined petroleum products must be cleaned to background levels or to levels shown through a contaminant leaching assessment to not lead to groundwater contamination through leaching nor pose a risk to potential surface receptors".

(2) Risk-based concentrations equivalent to a cancer risk of 1×10^{-7} or a hazard quotient of 0.1 (EPA 1994).

Key:

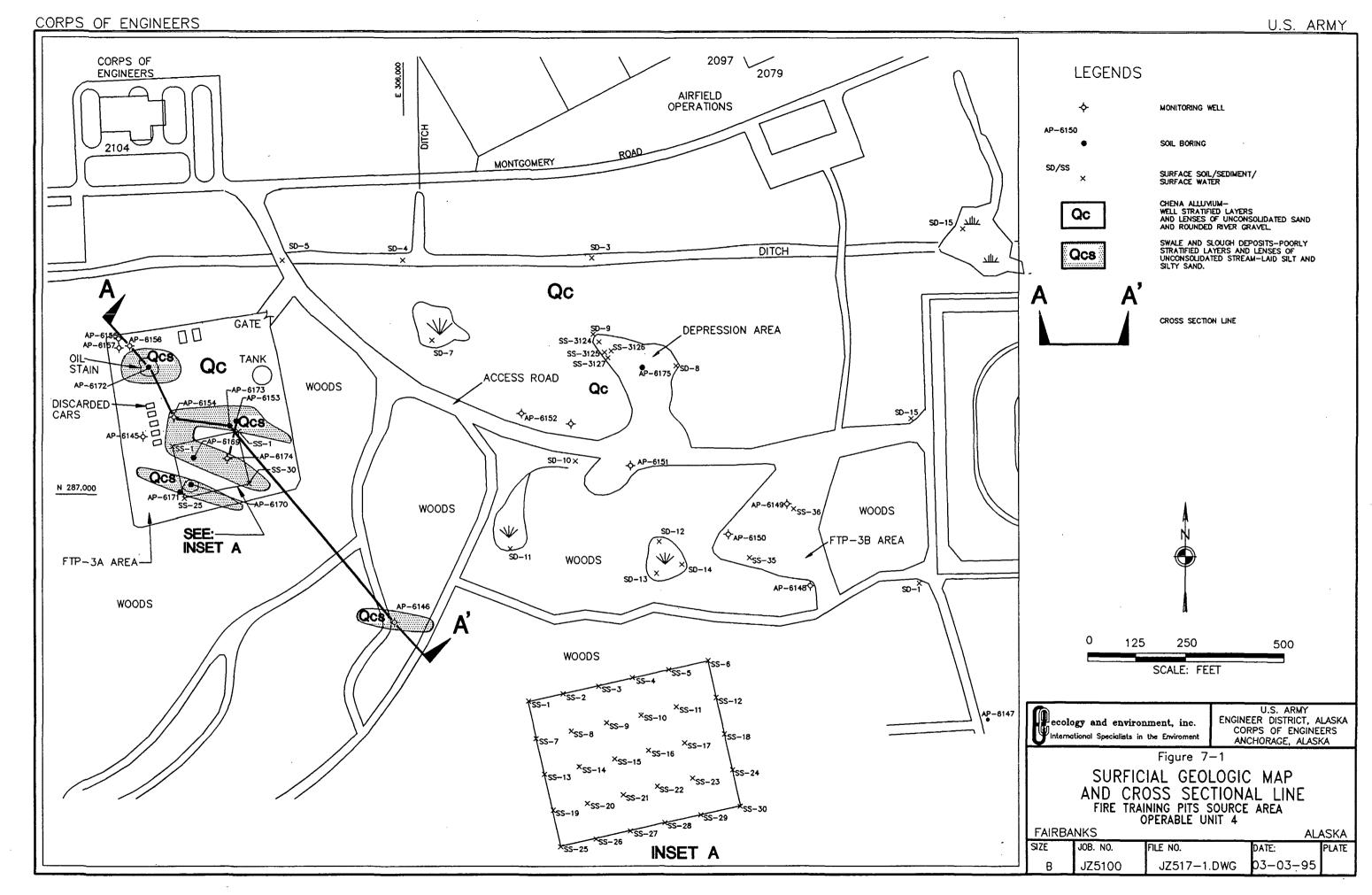
ARARs = Applicable or relevant and appropriate requirements.

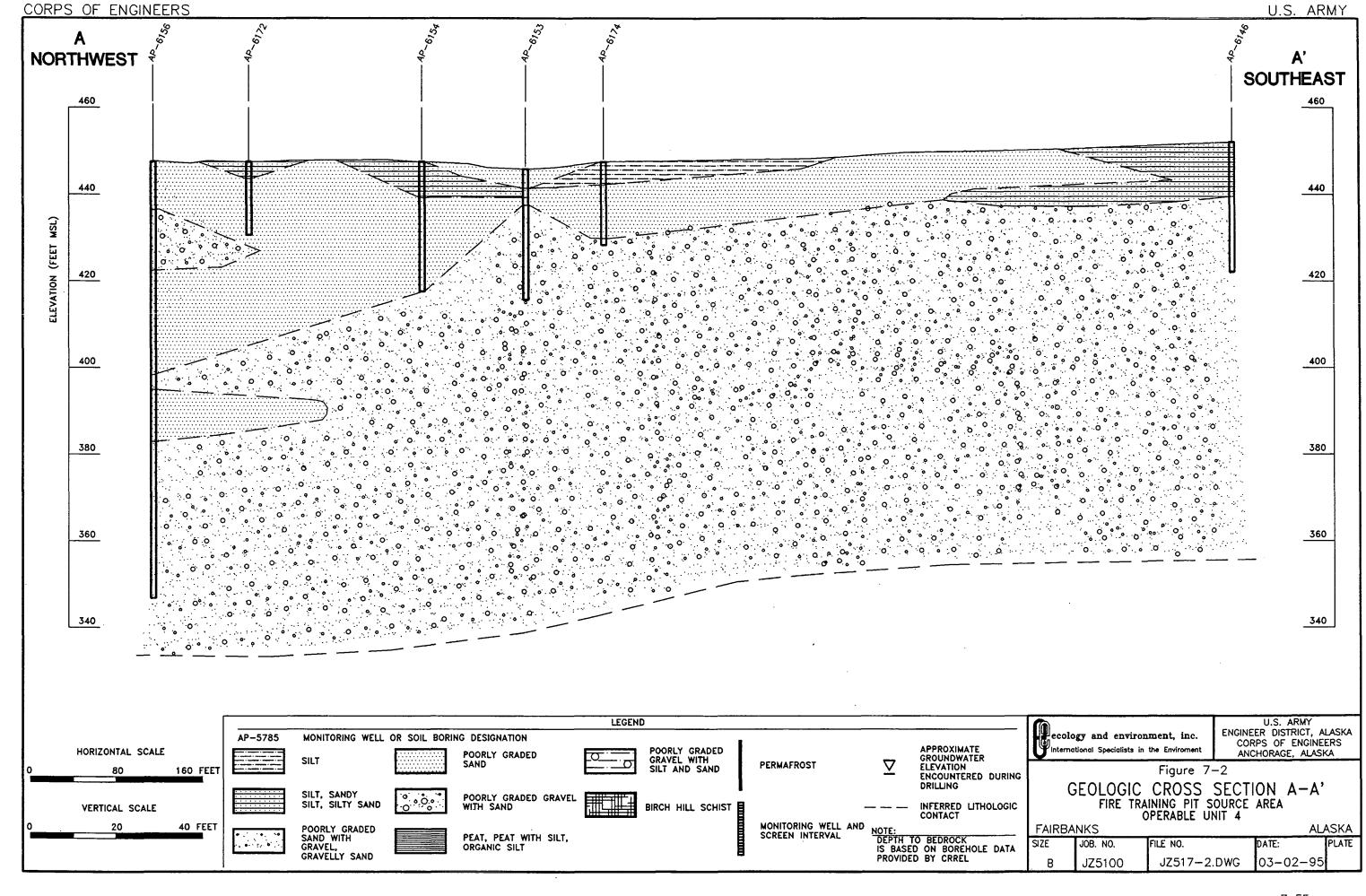
EPA = United States Environmental Protection Agency.

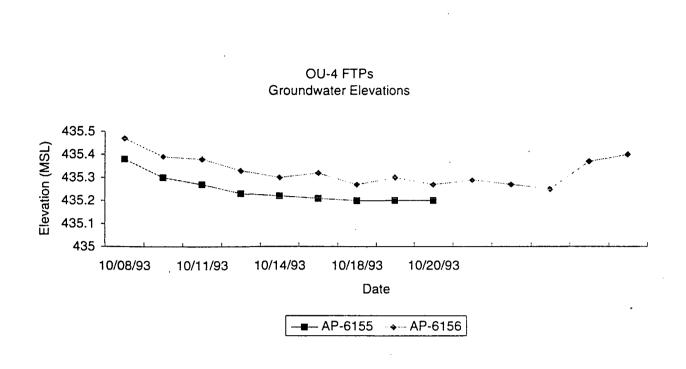
mg/kg = Milligrams per kilogram.

TBCs = To-be-considered criteria.

UST = Underground storage tank.

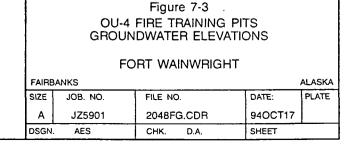






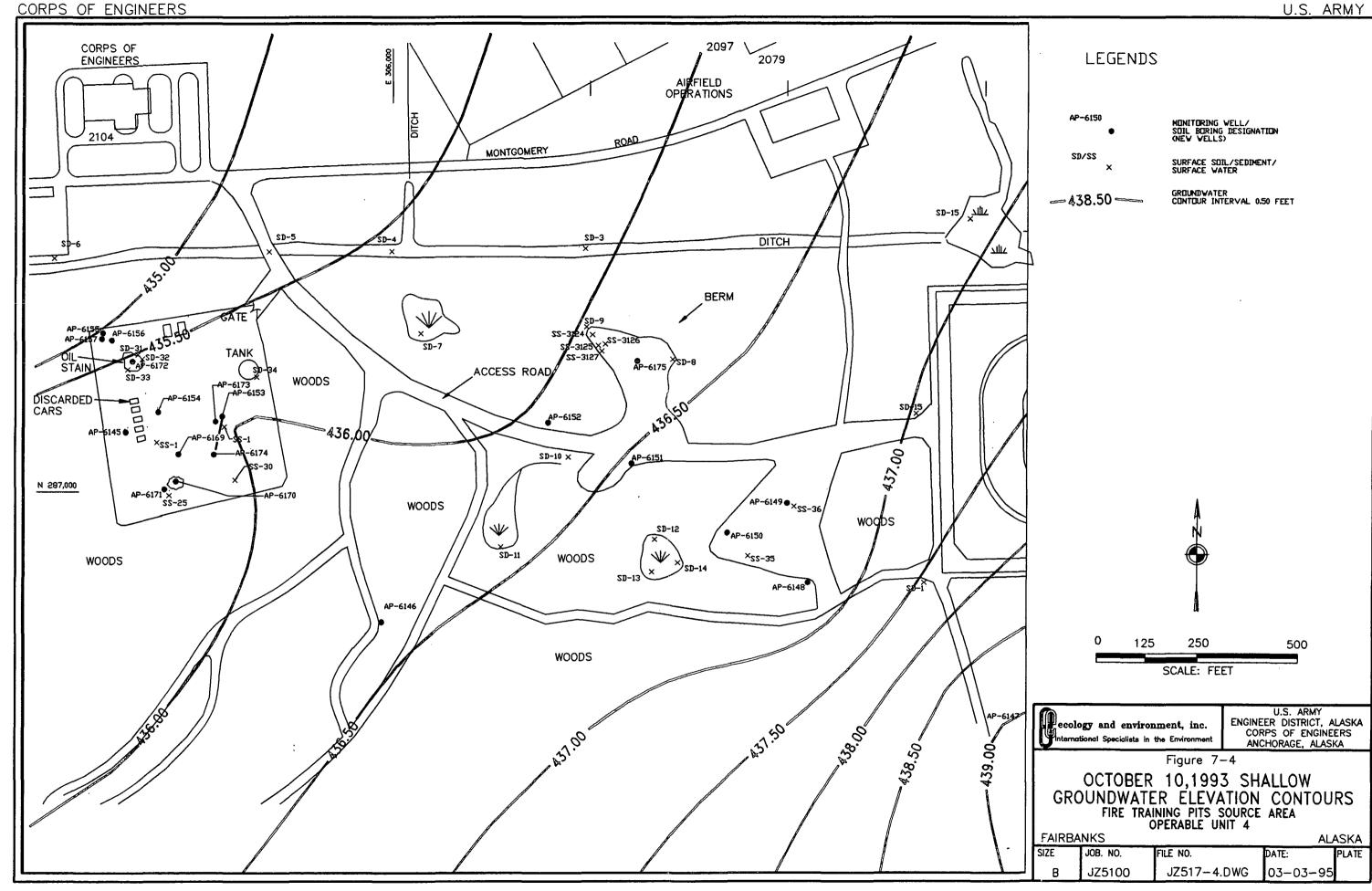
Aug - Nov 93 429 424 Chena Stage Elevation (MSL) 428 Elevation (MSL) 2128 Stage 427 4218 420 au 419 L 426 425 424 423 1 4 7 10 13 16 19 22 25 28 31 3 6 9 12 15 18 21 24 27 30 3 6 9 12 15 18 21 24 27 30 Day of Month - Chena River ---- Tanana River

Chena River vs. Tanana River

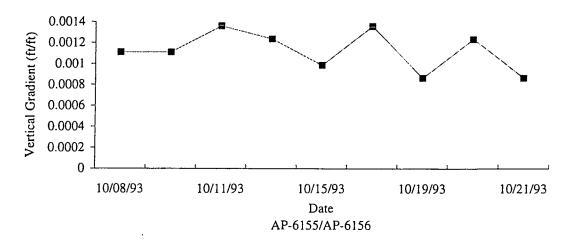


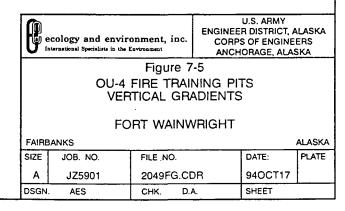
ecology and environment, inc.
International Specialists in the Environment

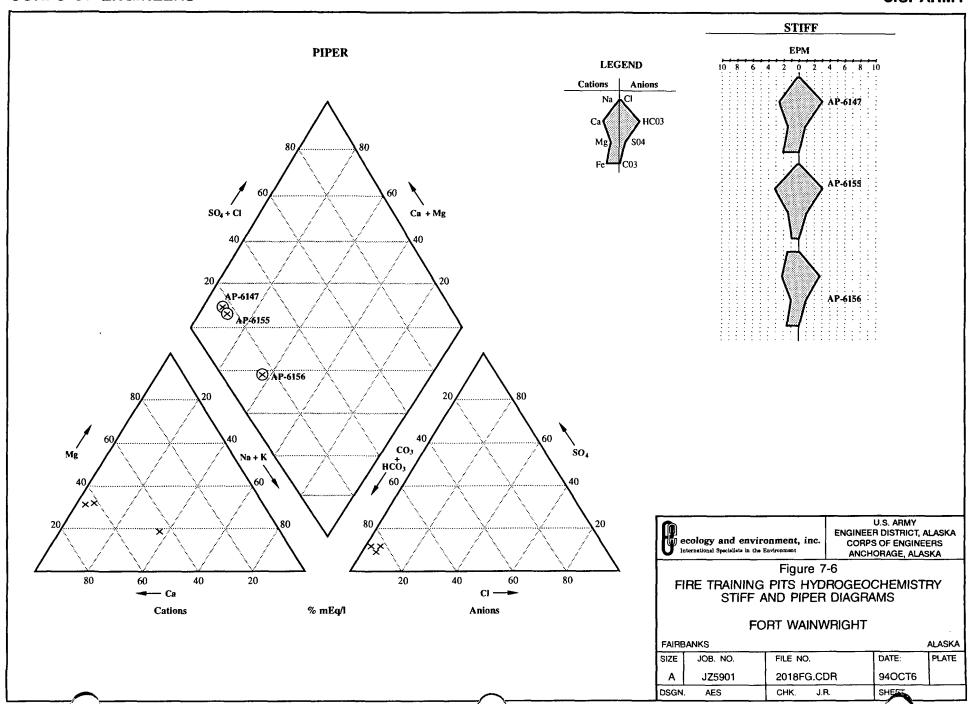
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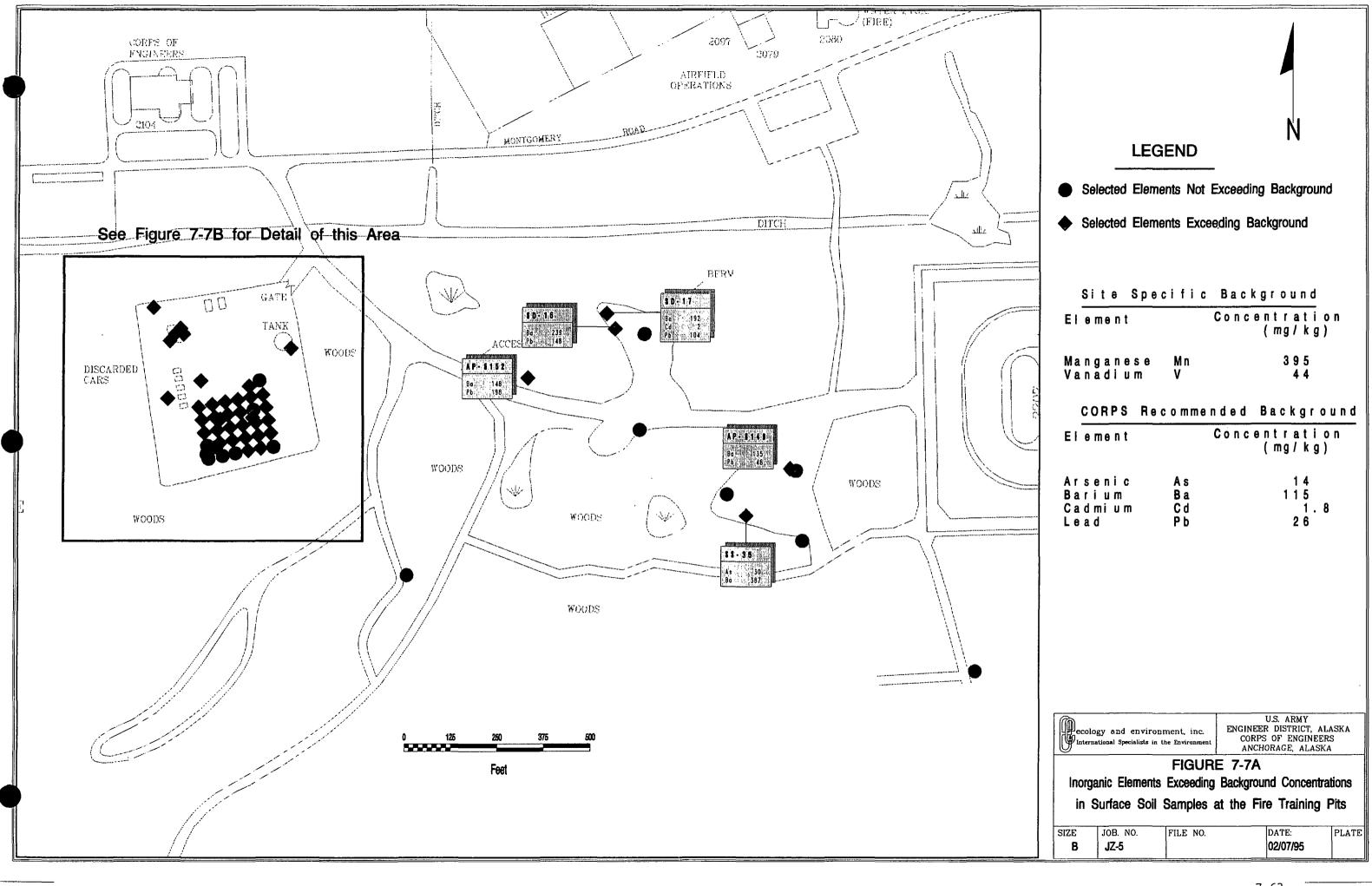


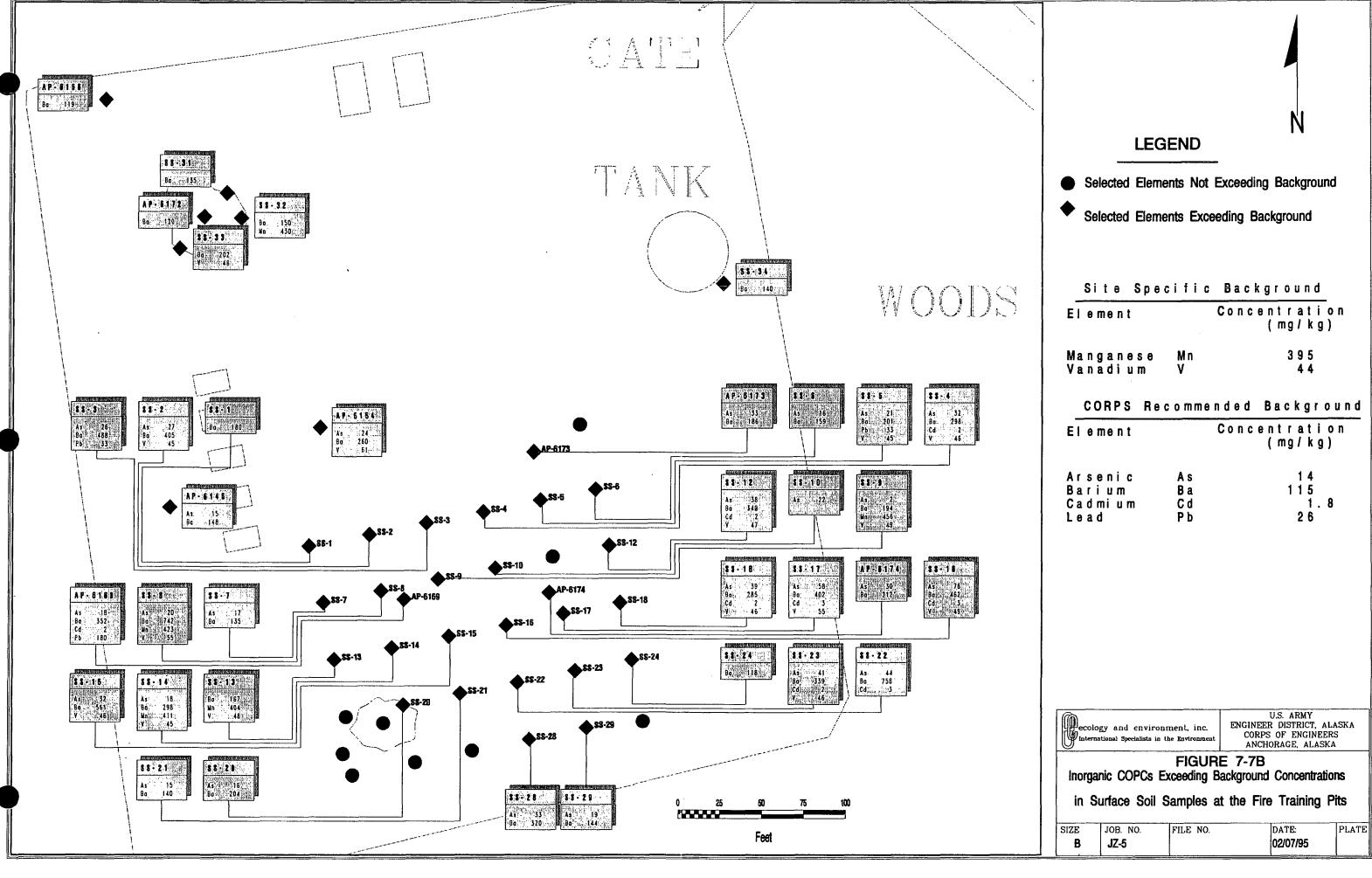
+ gradients reflect upward groundwater movement - gradients reflect downward groundwater movement

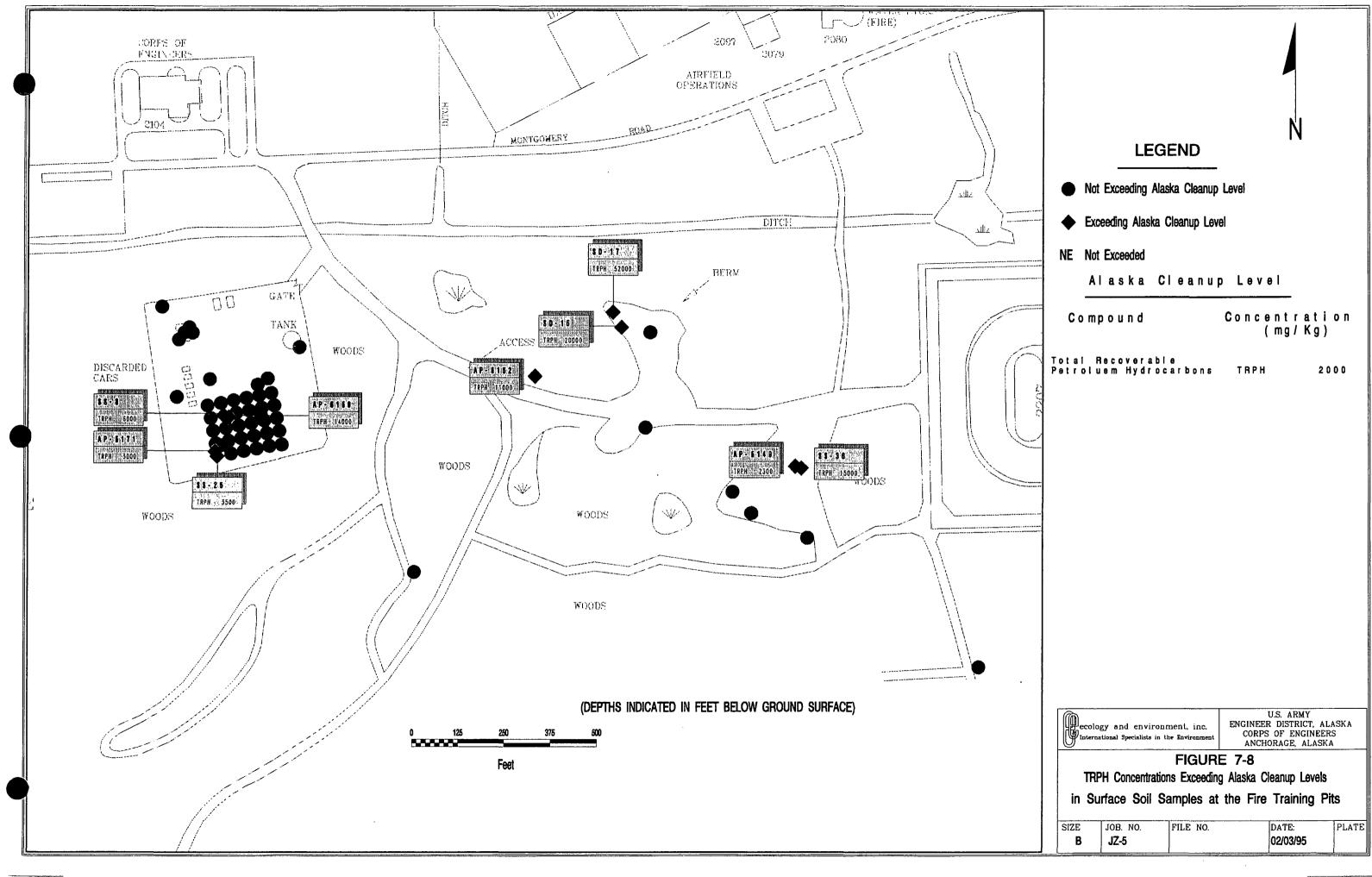


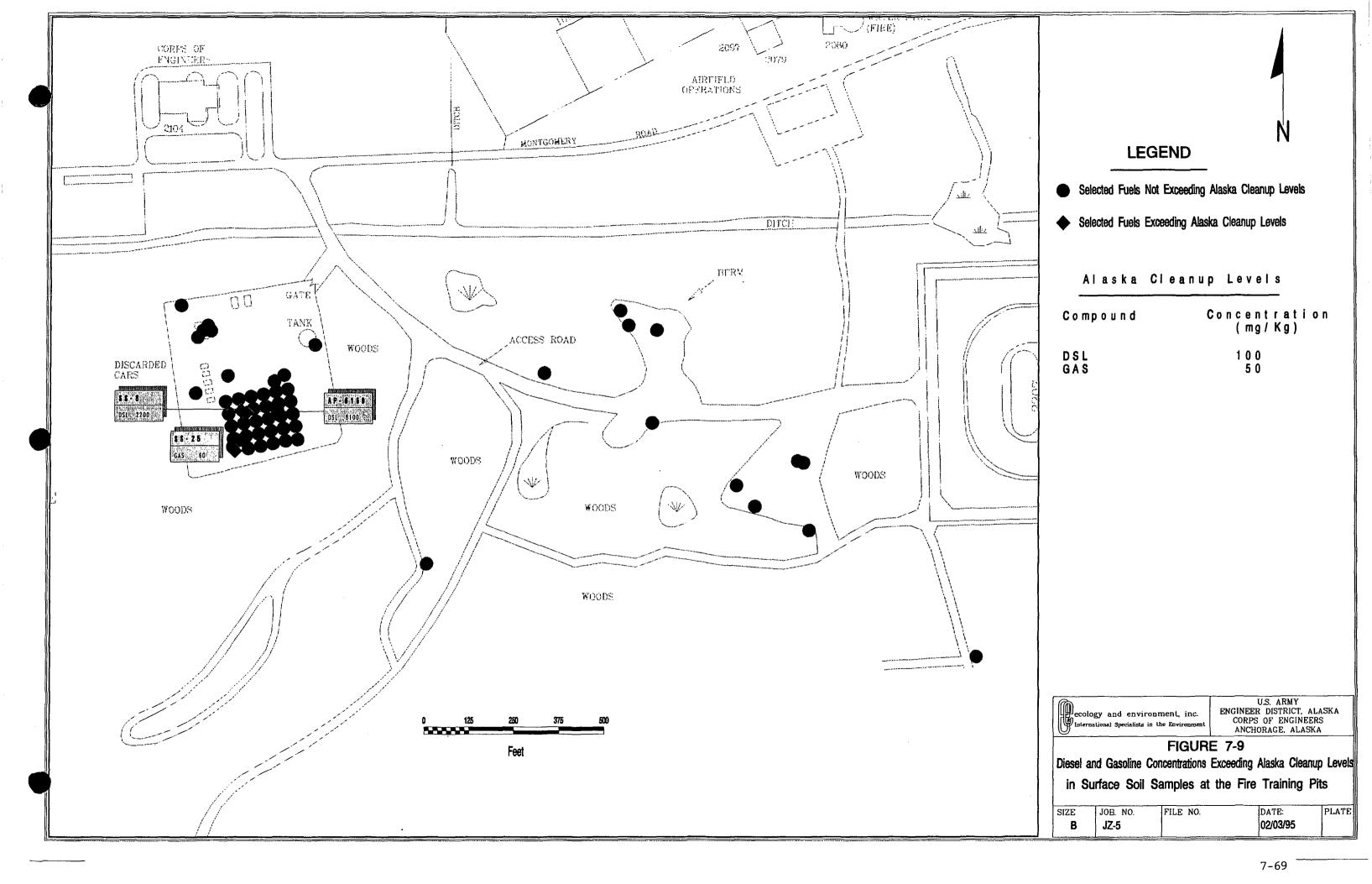


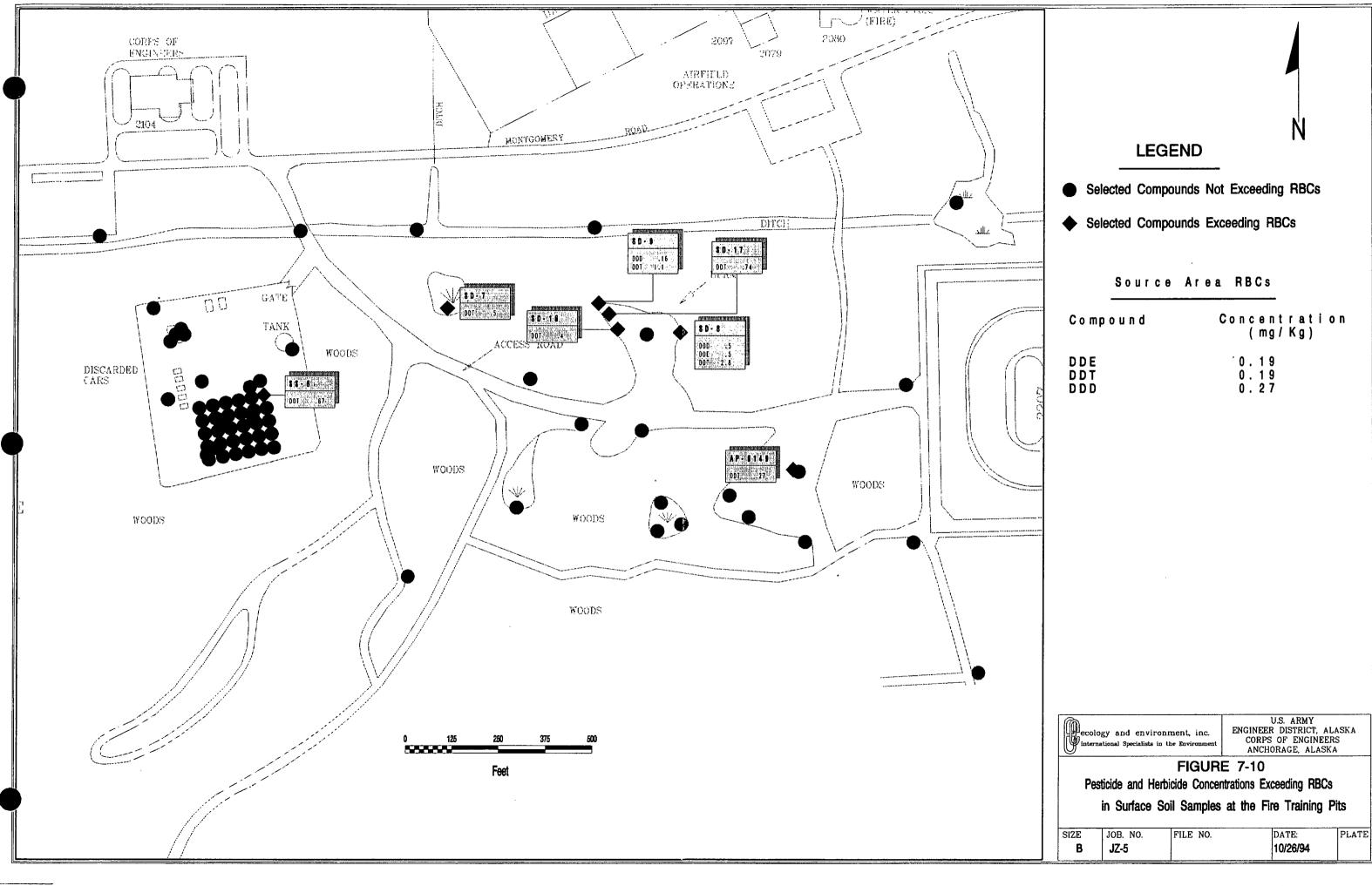


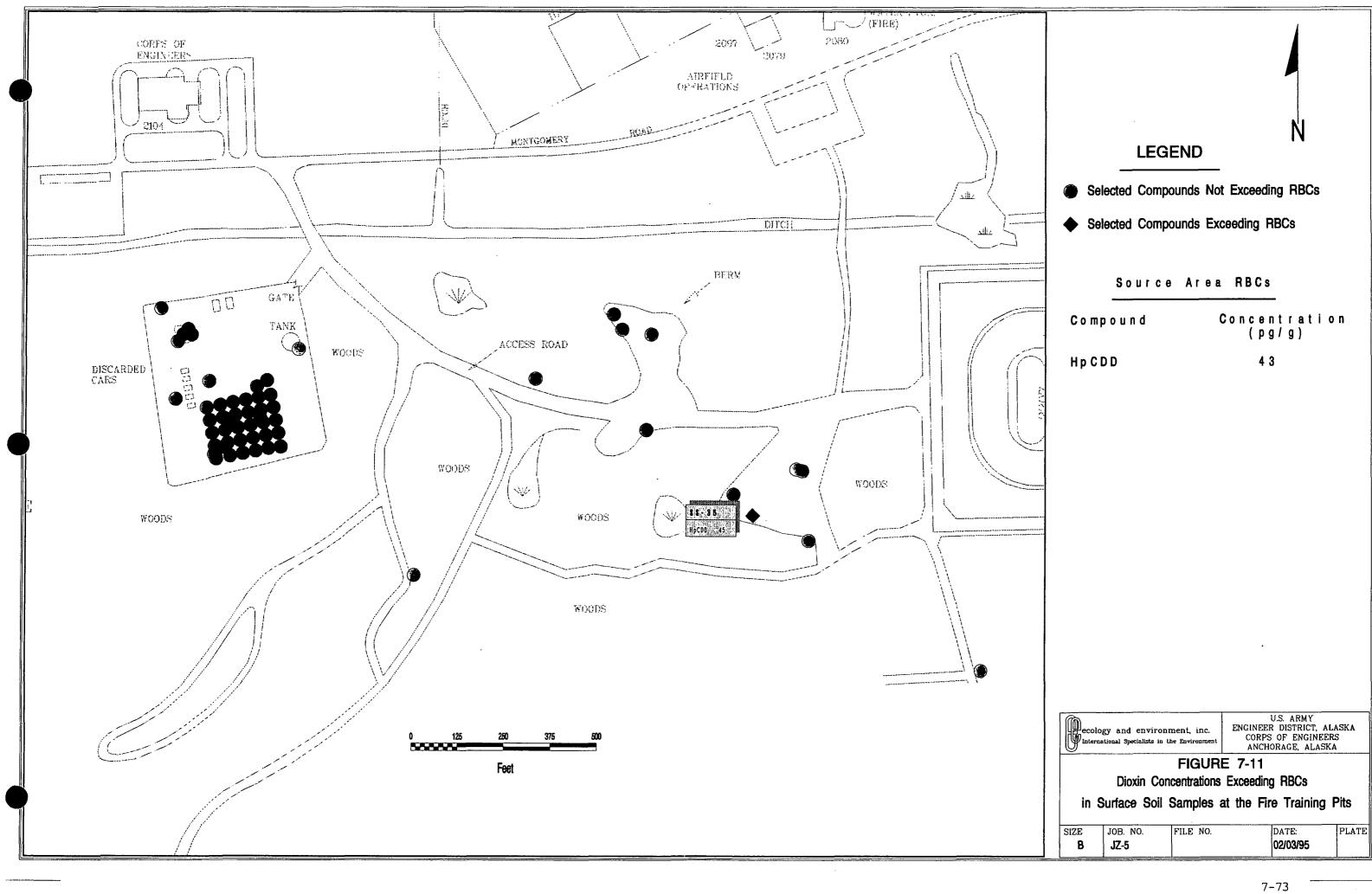


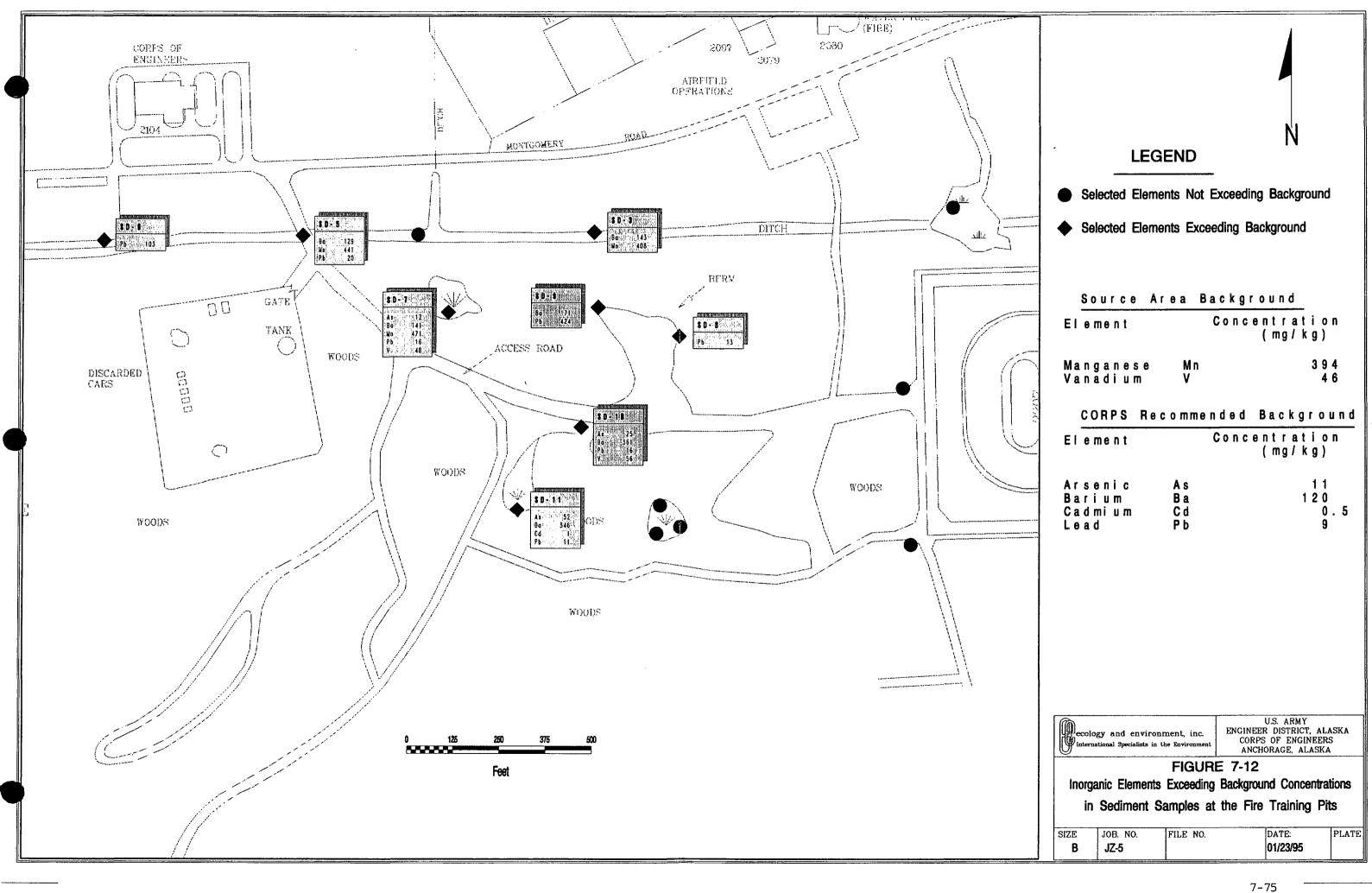


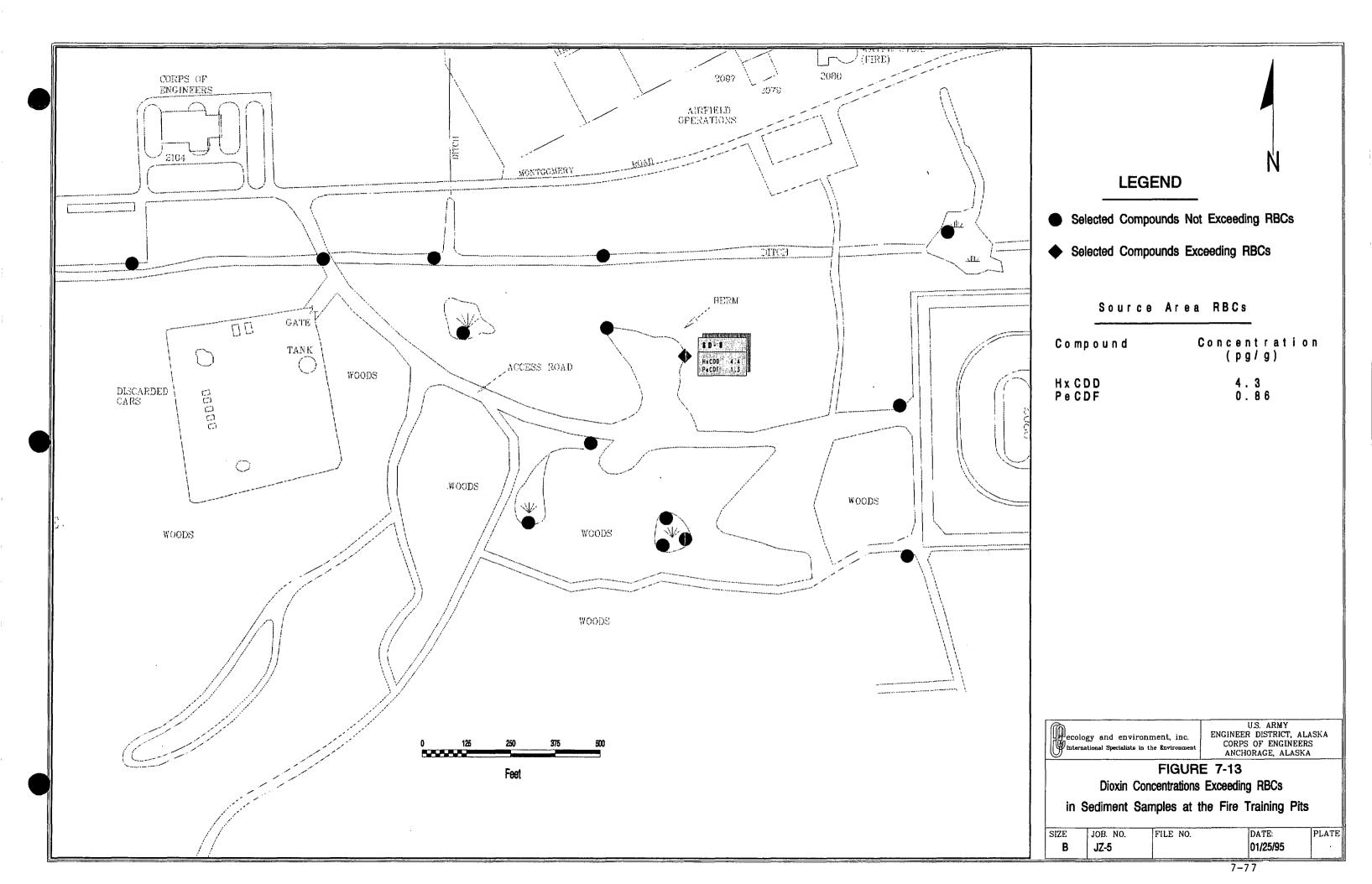


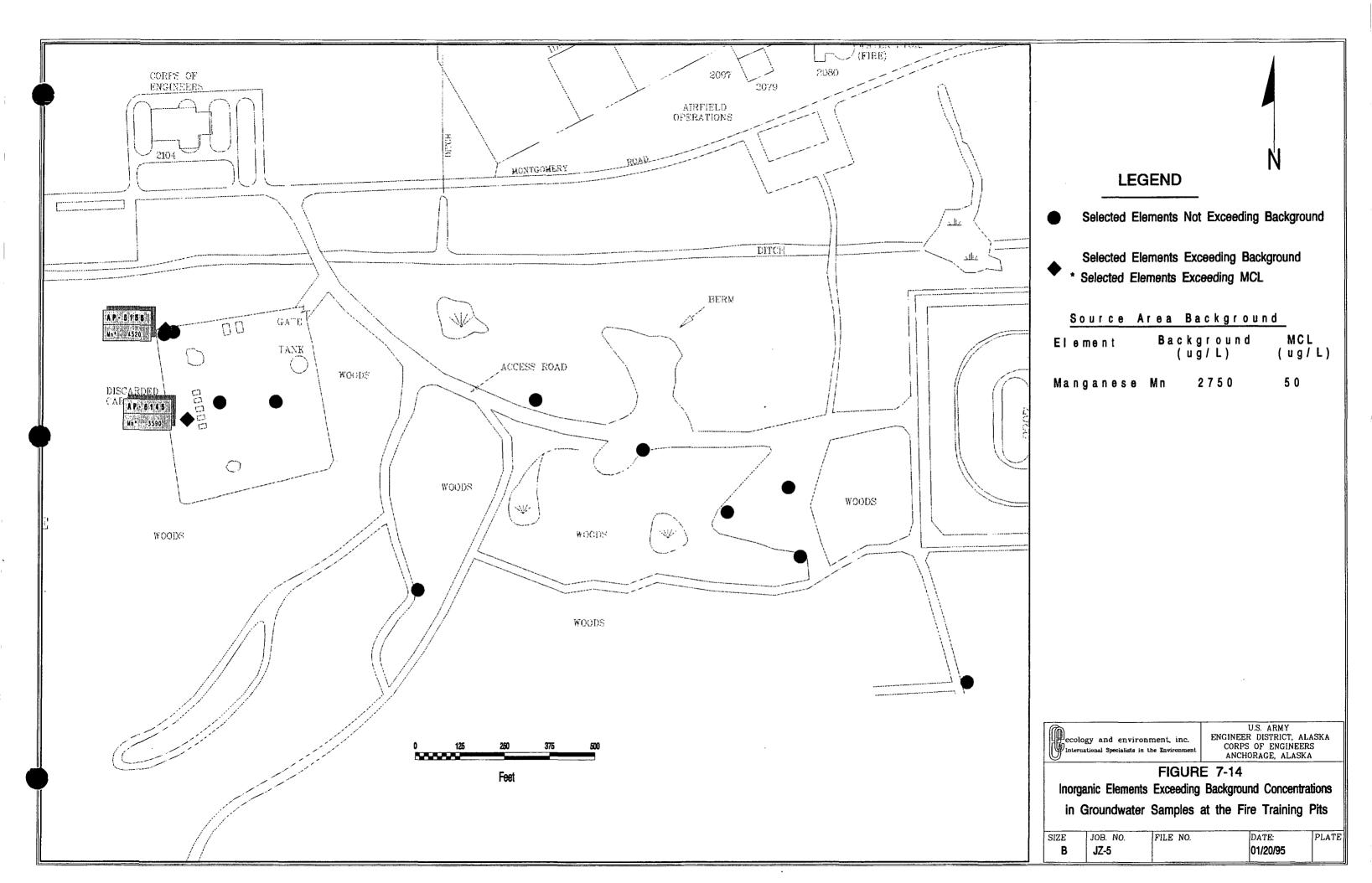


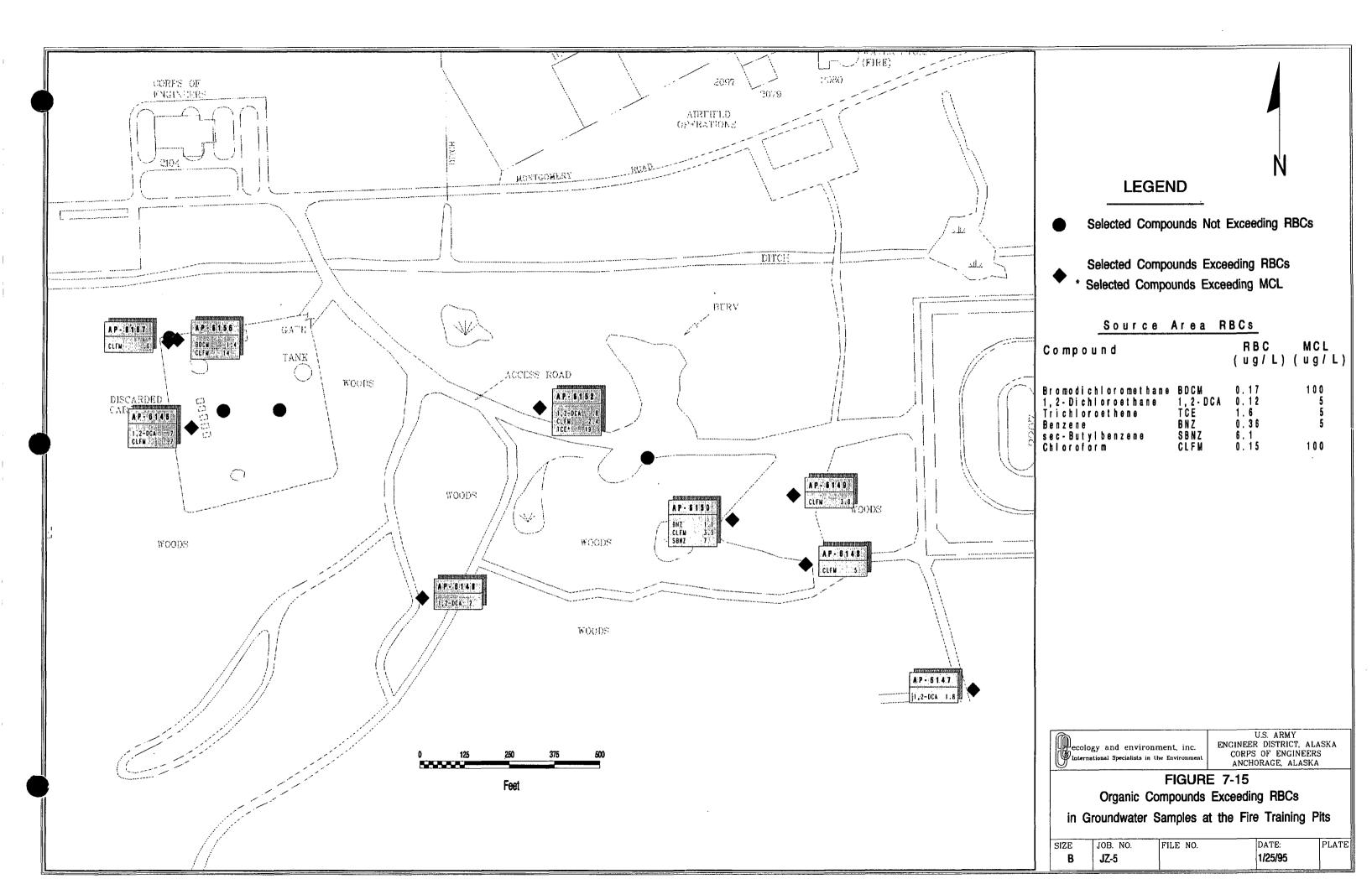


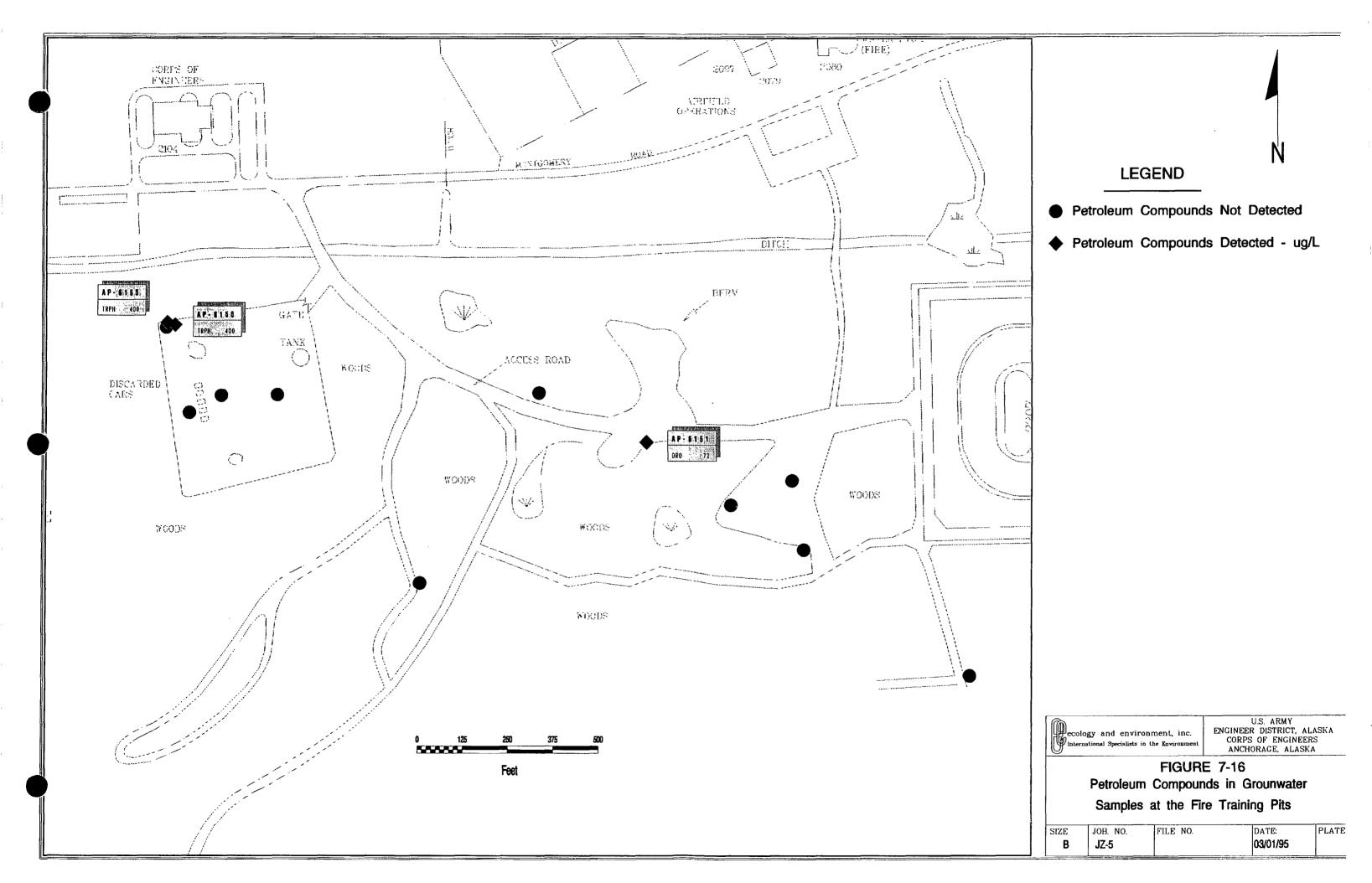












8. ENVIRONMENTAL FATE AND TRANSPORT OF CHEMICALS OF POTENTIAL CONCERN

The OU-4 Management Plan (E & E 1993) provided a preliminary analysis of the potential contaminant migration pathways as part of the conceptual site models. This section presents a discussion of the physical-chemical factors influencing the fate and transport of the COPCs for OU-4. Figure 8-1 is a conceptual schematic of basic fate and transport processes that may be affecting inorganic and organic COPCs.

As discussed in Sections 5, 6, 7, COPCs were identified based on the screening criteria described in Sections 5.2, 6.2, and 7.2. Chemicals known to have been used at a source area were included as COPCs only if they were detected at concentrations exceeding background values or at levels which potentially could impact human or ecological health. Certain chemicals, such as organochlorine pesticides, arsenic, vanadium, and lead, were included as COPCs because of the potential risks associated with the concentrations detected. However, their presence at the source area may not be attributable to site-related activities.

Due to the large number of COPCs for OU-4 source areas, inorganic and organic COPCs are discussed in Sections 8.1 and 8.2, respectively. The inorganic COPC subsection includes a general discussion of the fate of inorganic chemicals and a detailed analysis of the fate of each inorganic COPC. The organic COPC subsection provides a detailed discussion on the fate of organic chemicals and is supplemented with tables summarizing the specific physicochemical characteristics of the selected organic COPCs. The migration pathways presented in this section update and supplement the conceptual site models presented in the OU-4 Management Plan (E & E 1993).

8.1 EXPECTED FATE OF INORGANIC ELEMENTS

The ionic nature of inorganic chemicals results in fate and transport mechanisms dominated by ion competition for sorption sites and ion exchange reactions. The OU-4 inorganic COPCs include aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium (total Cr), copper, fluoride, lead, manganese, mercury, selenium, and vanadium. Several of these (aluminum, fluoride, selenium, and vanadium) are naturally occurring in soils, bedrock (present in minerals within the bedrock), and groundwater, and will not be discussed further in this section.

The Corps statistically developed background concentrations for arsenic, barium, cadmium, chromium, and lead in soils and groundwater at Fort Wainwright (Corps 1994). This data was used to determine if concentrations detected in samples could be attributable solely to natural soil, bedrock, or groundwater conditions.

The fate of these elements in the environment is largely determined by their water solubility and tendency to bind to soil and sediments. The extent of sorption in soils, sediment, or aquifer materials is dependent on the amounts of organic matter, clay, and iron and aluminum hydroxides, as well as the pH and Eh of the surrounding solid and aqueous medium. The ionic radius and valence state of the sorbed element are also important. High cation exchange capacity in clays facilitates sorption. However, laboratory grain size analysis of samples collected during this investigation indicated that the average clay content in the surface and subsurface soils was less than 1%, so this factor will have only a minor role in controlling transport in the study area.

Knowing the speciation is essential to predicting the behavior of an inorganic element. Additionally, it is critical that inorganic concentrations in the suspended sediments of a surface water body or in the matrix of an aquifer can be distinguished from dissolved concentrations in the water. Metals can occur in any of the following species (EPA 1989a):

- Free ions, surrounded only by water molecules;
- Insoluble species;
- Metal and ligand complexes;
- Sorbed species, including coordination bonding of inorganics to specific surface sites;

- Species held on a surface by ion exchange (inorganics held by electrostatic forces); and
- Species that differ by oxidation state.

Each of the metals of potential concern at OU-4 has its own chemistry that affects fate and transport in the environment. The most applicable predictive transport factor that applies to the fate of inorganics is water solubility. In general the inorganic COPCs for OU-4 are soluble and exhibit affinities for organic and/or inorganic matter. Therefore, surface water runoff, leaching and infiltration, and groundwater transport will all be primarily responsible for the transport of the inorganic COPCs. Their affinity for organic and inorganic matter will result in inorganic COPCs adsorbing to particulate matter in surface and subsurface soils, and surface water. If transported to surface water, any adsorbed contaminants are likely to be deposited, over time, to the sediments. Therefore, the fate of the inorganic COPCs at OU-4 is most likely to be in surface or subsurface soils, and aquatic sediments. Because of the relatively high water solubility of many inorganics. The inorganic COPCs may also be found in the groundwater and surface waters, but at concentrations less than those in soils and sediments.

8.1.1 Antimony

Antimony (Sb) exists in oxidation states +3, +5, and -3; however, the -3 state is not stable in oxygenated water. Antimony is included in alloys in the metals industry, and antimony oxides were probably present in grid plates found in batteries. Antimony is also included as a hardening agent in bullet "jackets."

In aquatic systems, very few of the antimony oxides occur in the dissolved state. Those that do dissolve are present as various hydrolysis products such as Sb(OH)₃ and HSbO₂. Antimony is predominantly associated with suspended particulates, which sorb onto sediments over time. The rate of removal from the water column is dependent on such factors such as salinity, changes in pH, and amount of current or turbulence present in the water systems. Bioaccumulation of antimony species other than metallic antimony was shown to be insignificant for most aquatic species.

In soil, antimony oxides (tri-, tetra-, and peta-) are expected to be persistent due to their low water solubility, high stability, and low vapor pressure.

8.1.2 Arsenic

Arsenic (As) is a nonmetallic element with stable oxidation states that include both anionic and cationic forms. Sorption to hydrous iron oxides or coprecipitation tends to reduce the mobility of arsenic in the environment.

Arsenic has four stable oxidation states: 5+, 3+, 0, and 3-. As5+ and As3+ are the most common oxidation states in aqueous environments. As5+ and As3+ are readily converted by biological and chemical redox reactions. Arsenates (As5+), predominate in most soils, while arsenite (As3+) dominate in reducing environments such as in sediments and subsurface soils. As3+ species are generally more mobile than As5+ in the subsurface. Arsenic may leach into groundwater, especially from soils with low sorptive capacity (EPA 1984a). Arsenic also has been used as a component of pesticides. The primary processes limiting the mobility of arsenic in soils are precipitation as metal salts, coprecipitation with iron or manganese oxides, substitution for phosphorus in soil minerals, and adsorption to amorphous metal oxides. Bioaccumulation factors for arsenic in aquatic organisms are very high and reportedly range from 5,000 to 6,000. They are highest at the lower trophic levels (EPA 1979).

8.1.3 Barium

The solubility of barium carbonate is similar to that of calcite. A likely control over the concentration of barium in natural water is the solubility of barite (BaSO4), which is a fairly common mineral. Another factor that seems likely to influence the concentration of barium in natural waters is adsorption by metal oxides or hydroxides (Hem 1989). Little information is known about the transport of barium in soils. However, one adsorption experiment found that no significant adsorption occurred (Roy et al. 1987).

8.1.4 Beryllium

Beryllium oxide and hydroxides have very low solubilities as compared to the more soluble sulfate and carbonate compounds. Beryllium can form anionic fluoride complexes that increase its aqueous mobility (Hem 1989). Adsorption data is limited on beryllium. However, based on its geochemical similarity to aluminum, beryllium is expected to form some insoluble complexes under high pH conditions and at low pH conditions sorbs onto clay minerals (EPA 1979).

8.1.5 Cadmium

In natural waters, cadmium exists as hydrated ion, metal-inorganic complexes with carbonate, hydroxyl, chlorine, or sulfate anions, or as metal-organic complexes with humic acids. Cadmium concentrations are typically low in groundwater due to sorption by mineral matter and clay, binding to humic substances, precipitation as cadmium sulfide in the presence of sulfide, and precipitation as cadmium carbonate at high pHs. In soil, cadmium may occur bound to soil minerals or organic constituents, as free cadmium compounds, or as the divalent ion dissolved in soil moisture. High soil acidity favors release of the divalent cadmium cation and facilitates uptake by plants (ATSDR 1989). Cadmium is in zinc ore minerals, such as sphalerite, and is used in electroplating processes, electrical batteries, and video tubes.

8.1.6 Chromium

Chromium (Cr) occurs in two oxidation states in aqueous systems: Cr3+ and Cr6+. Cr6+ is more toxic than Cr3+. Trivalent chromium (Cr3+) reacts with hydroxide ions in water to form insoluble chromium hydroxide, Cr(OH)₃, which is rapidly removed from water by precipitation and sorption to soils or sediments (EPA 1984b). Hexavalent chromium (Cr6+) forms soluble chromate and dichromate anions, which are not strongly sorbed to soils or sediments, and are therefore mobile in the environment (EPA 1984b). Cr6+ and Cr3+ can be converted in soils or surface water under conditions that change the redox potential of the system (EPA 1979).

Chromium can be transferred up the food chain, but does not appear to be magnified at higher trophic levels in a food chain (EPA 1984b). Chromium does not appear to undergo biological transformation reactions such as methylation, but Cr6+ can be chemically reduced to Cr3+ upon contact with plant or animal tissue. Ultramafic rocks are higher in chromium than other rocks. Chromium is used in electroplating processes.

8.1.7 Copper

Copper (Cu) can be found in three oxidation states: Cu0, Cu1+, and Cu2+. Of these three, only the Cu2+ oxidation state is found in aquatic systems. Copper can also form complexes with cyanide, amino acids, and humic substances. In the absence of organic complexing agents, hydrolysis and precipitation of copper oxide dominate copper's chemistry in aqueous environments.

The interactions of copper with organic materials in natural waters have been studied extensively. Organocupric interactions result in the increased solubility of some copper-containing minerals and the subsequent transport of the organocupric complex (Rashid and Leonard 1973). Hydrous metal oxides can sorb copper and render it immobile (Jenne 1968). This sorption process occurs in competition with binding of other metals, and competitive adsorption could result in the release of copper. Copper as cupric oxide has a molecular weight of 79.5 g/mole and is practically insoluble in water and organic solvents (Farm Chemicals Handbook 1988). Copper is used extensively for water pipes and plumbing fixtures, as an additive to water supply reservoirs to suppress algal growth, and in agricultural pesticide sprays.

8.1.8 Lead

The movement of lead in aquatic environments is influenced by lead speciation. In water with high concentrations of dissolved organics, complexation is an important mechanism for retaining lead in solution. In waters without substantial dissolved organics, lead can become sorbed to suspended particulates and eventually settle out.

The sorption process exerts dominant effects on the distribution of lead in aquatic and terrestrial environments. Sorption to inorganic solids, organic materials, hydrous iron, and manganese oxides controls the mobility of lead in soils and sediments.

The dominant sorption mechanisms are dependent on geological setting, pH, and Eh (EPA 1986).

Bioaccumulation of lead has been demonstrated for a variety of organisms, with bioconcentration factors typically ranging from 42 to 1,700 (EPA 1986). Lead, historically used in lead pipes, occurs as sulfuric ore bodies. It also is used as an additive to gasoline.

8.2 EXPECTED FATE OF ORGANIC CHEMICALS

Table 8-1 presents a list of the primary organic COPCs and their associated physical and chemical properties. The table lists the organic COPCs in the following groups:

- Volatile organic compounds (VOCs),
- Dioxins (PCDDs),
- Organochlorine pesticides, and

• Polynuclear aromatic hydrocarbons (PAHs).

The list of chemicals presented in Table 8-1 includes representative compounds in each chemical grouping that are subsequently discussed in the text. For example, although several VOC isomers were detected in various media samples, only the properties of TCE, DCE, and xylenes are discussed specifically due to availability of data and the documented toxicity of these compounds. PCDDs, PAHs, and pesticides are large complex molecules, with densities greater than water, low water solubilities, low volatilization rates, and high partitioning coefficients. These compounds are relatively persistent in environmental media when compared with VOCs. A discussion of the general physical and chemical properties affecting the mobility and possible transformation reactions of these representative organic COPCs for the OU-4 source areas follows.

8.2.1 Physical Form and Miscibility

In pure form, most of the organic COPCs at the OU-4 source areas, with the exception of possibly the VOCs and the aromatic hydrocarbons, would exist as solids over the range of ambient air pressures and temperatures expected to occur at the site (see Table 8-1). The organic COPCs that have been associated with past practices at OU-4, with the exception of the aromatic hydrocarbons (toluene and xylenes), have densities greater than water. Typically, contaminants were mixed with both lighter and denser than water carrier oils, solvents, and associated liquid compounds to make these contaminants easier to utilize. The carrier fluids were typically mixtures of various hydrocarbons that included PAHs, and may have included aromatic hydrocarbons.

Several of the contaminants are generally insoluble in groundwater (with relatively low water solubilities as shown in Table 8-1). Several pesticides detected also are considered priority leachers (i.e. dieldrin, methoxychlor), which may be expected to contribute to groundwater contamination. Additionally, pesticides are biologically and chemically restrictive and are by nature able to reach groundwater before degrading (Mansour 1993). Several of these organic chemicals were likely introduced to the site primarily in multicomponent mixtures rather than in single chemical form, particularly at the CSY and FTPs, and the solubilities of the individual chemicals are dependent on the mixture. Cosolvency effects may allow a chemical that is only sparingly soluble in water to exist at much higher concen-

trations in solution as multicomponent mixtures than its solubility would normally dictate (Keely 1989).

Contaminants and/or fluids containing contaminants that may have been discharged to the subsurface and infiltrated to groundwater may exist as light non-aqueous phase liquids (LNAPLs, "floaters"), or dense non-aqueous phase liquids (DNAPLs, "sinkers"), respectively. LNAPLs and DNAPLs migrate to the groundwater table after sufficient volume collects to overcome the soil pore pressures and partitioning within the unsaturated zone and move with gravity toward the saturated zone, leaving residual contaminants in the unsaturated soil, as the advancing front moves downward. LNAPLs and DNAPLs continue to move downward and accumulate on the capillary fringe above the groundwater table until a sufficient volume of the immiscible fluid has accumulated to overcome the negative capillary pressures and displace the water from the soil pores (EPA 1992).

LNAPLs tend to pool on top of the groundwater table (since LNAPLs are lighter than groundwater), and if sufficient LNAPL volume exists move under similar hydraulic influences as groundwater. LNAPLs then begin to partition into a dissolved phase and a gaseous phase in the groundwater if solubilities and partitioning values are sufficiently high. The free-product LNAPLs generally move more slowly than the surrounding groundwater due to retardation (attenuations, sorption, etc.) effects and the necessity to overcome new soil pore pressures. The dissolved LNAPL component generally moves faster than the free-product, but slower than groundwater because of retardation effects.

Once a sufficient volume of the DNAPL has accumulated at the groundwater interface to displace the water, DNAPLs sink through the groundwater and continue to migrate downward through the water column until the bottom of the aquifer or less permeable (and unfractured) medium is reached, or until product volume is exhausted and a chemical or physical equilibrium is achieved. DNAPLs begin to partition into the groundwater dissolved phase if solubilities are sufficiently high. Because of their immiscibility and high density, DNAPLs in groundwater preferentially migrate downward through the saturated zone and typically exhibit inhibited horizontal movement, depending on the groundwater flow potential.

Residual LNAPLs and DNAPLs typically remain, with limited further migration, in the surface soil, subsurface soil (unsaturated zone), and saturated aquifer materials through which they travelled. Generally, the volume of LNAPLs present in saturated aquifer material transversed by LNAPLs has a lower vertical component (limited primarily by fluctuations in

the groundwater table) and a greater horizontal component (area of LNAPL plume). Conversely, the volume of DNAPLs present in saturated aquifer material transversed by DNAPLs has a lower horizontal component (area of initial pooled material, whether on the groundwater table or an impermeable surface) and greater vertical component (limited by the depth at which an impermeable surface is reached or by product volume; EPA 1992).

In the groundwater, soluble portions of residual DNAPLs are leached by infiltrating water or moving groundwater, and travel through advection. Advection is the process by which the bulk motion of flowing groundwater transports chemicals. The movement of chemicals in the water is also influenced by dispersion. Dispersion is the result of molecular diffusion (movement from high to low concentrations) and mechanical mixing (the result of variations in groundwater flow). Chemicals that comprise DNAPLs are rarely found in groundwater at their solubility limits because of diffusional limitations and dispersion. Concentrations as low as 1% of the chemical solubility may indicate the presence of a DNAPL (EPA 1992a). Small variations in aquifer materials can control the preferred path of DNAPL movement resulting in a tortuous decent through the aquifer. As DNAPLs travel through saturated and unsaturated media, residual DNAPLs remain along the travel path. It is estimated that the fraction of total pore space containing DNAPLs typically ranges from 5 to 20% in unsaturated soils, and 15 to 50% in saturated soils through which DNAPLs have travelled (EPA 1992a). This residual DNAPL is not easily defined in, or removed from, the aquifer. Given the difficulties in delineating the extent of DNAPLs in the aquifer, estimating the volume of DNAPLs in an aquifer is a very difficult task, even if the initial volume released to the aquifer is known.

LNAPLs more typically form a discrete layer on the water table. Samples of LNAPLs can usually be collected from wells which are screened across the water table-LNAPL interface within the LNAPL layer. Collection of an LNAPL requires sufficient open area within the screened portion of the well to allow the LNAPL to enter the well screen due to the generally greater viscosity. Obtaining an LNAPL sample is more difficult in locations with fluctuating water tables. Less viscous water responds more quickly than more viscous LNAPLs to water level fluctuations. Dropping water levels will cause the LNAPL level to drop as well. A rapidly rising water table can trap LNAPLs beneath the water table (Kemblowski and Chiang 1990).

Wells may not provide a reliable measure of the thickness of a LNAPL plume. LNAPL thickness observed in a well will likely be less than the actual thickness of LNAPL in the aquifer when:

- LNAPL is trapped beneath the water table,
- The screen type or slot size impedes LNAPL flow into the well, or
- The sand pack may be less permeable than the surrounding aquifer.

In other cases, the sand pack and the well bore may be much more permeable than the surrounding aquifer, facilitating pooling of LNAPLs in the immediate vicinity of the well, and resulting in an overestimation of LNAPL thickness.

8.2.2 Volatilization

A compound's volatilization rate from water depends on its vapor pressure and water solubility. Vapor pressure is a relative measure of the volatility of a chemical in its pure state, and is an important determinant of the rate of vaporization from waste sites. Highly water-soluble compounds generally have lower volatilization rates from water than compounds having a low water solubility. The Henry's Law Constant is the ratio of the compound's vapor pressure (in atmospheres) to its concentration in water (in moles/m³). As the Henry's Law Constant concentration approaches zero, it becomes a more accurate measure than vapor pressure for predicting volatilization of the chemical to air from water. Compounds with Henry's Law Constants greater than approximately 10⁻³ can be expected to volatilize readily from water. Those with values ranging from 10⁻³ to 10⁻⁵ volatilize less readily, while compounds with values less than 10⁻⁵ volatilize slowly (Lyman, Reehl, and Rosenblatt 1982). Values for Henry's Law Constant (H) are defined by the following equation:

H (atm - m³)/mole) =
$$\frac{\text{vapor pressure (atm)} \times \text{MW (g/mole)}}{\text{water solubility (g/m}^3)}$$
 [Eq. 8-1]

Many of the organic COPCs, with the exception of the aromatic hydrocarbons, are not particularly volatile compounds, with low vapor pressures ranging from 2.50×10^{-5} to 9.59×10^{-11} mm Hg (for 4,4-DDT and benzo(k)fluoranthene, respectively, and with Henry's Law Constant ranging from 3.6×10^{-3} to 4.58×10^{-7} atm-m³/mol (dioxins/furans and

dieldrin, respectively; see Table 8-1). In contrast, the aromatic hydrocarbons are volatile, with vapor pressures of approximately 10 mm Hg and Henry's Law Constant greater than 5 \times 10⁻³ atm-m³/mol (see Table 8-1).

8.2.3 Sorption and Retardation

Sorption is the process by which either absorbtion and adsorption is the controlling factor in the attachment or partitioning of a compound usually in the aqueous phase to a media solid (clay, carbon) through which it is migrating.

Retardation describes the resistance to transport of contaminants through the subsurface. Not all contaminants are transported at the same rate, because the rate is affected by physical and chemical reactions.

Sorption of organic chemicals is primarily dependent on the fraction of soil organic matter in the aquifer. Residual petroleum oils also serve as a sorptive media for organic chemicals (Boyd and Sun 1990). The tendency for residual oils to form a sorptive media for organic chemicals can be estimated based on the octanol-water partition coefficient (K_{ow}) of the organic chemical. K_{ow} is a measure of how a chemical is distributed at equilibrium between octanol and water. Chemicals with higher K_{ow} s have a greater tendency to sorb to oily residues. The log K_{ow} s for the organic chemicals on the site are generally high (2.73 to 5.61; see Table 8-1). The organic carbon partition coefficient (K_{oc}) is a chemical-specific measure of the tendency for organics to be sorbed by the organic matter found in soil and sediment and is expressed as:

$$K_{oc} = \frac{\text{mg sorbed/kg organic carbon}}{\text{mg chemical dissolved/liter of solution}}$$
 [Eq. 8-2]

 $K_{\rm oc}$ values for organic chemicals range from 1 to 10^7 , with higher values indicating greater sorption potential. Chemicals with values of $K_{\rm oc}$ less than 1,000 generally do not sorb strongly enough to soils to affect overall leachability at normal soil organic content levels, which are generally below 1% (EPA 1979). The fraction of organic carbon was measured from samples collected from the subsurface materials during the field investigation (see Appendix I for analytical data). Sample results indicate that the average carbon content is approximately < .1% in subsurface materials and <5% in surface soils. Sediments have higher carbon contents but typically do not exceed 10%. With the exception of the VOCs, all of the organic COPCs for OU-4 have $K_{\rm oc}$ values greater than 1,000 (see Table 8-1).

Sorption is often described in terms of the distribution of the chemical between the groundwater and aquifer materials. The distribution or partition coefficient (K_d) of low concentrations (i.e., at concentrations no more than approximately half the solubility of the chemical) of nonpolar chemicals is often described using a linear Freundlich isotherm (Karickhoff, Brown, and Scott 1979) where K_d is defined as:

$$K_d = \frac{\text{mg of solute on the solid phase/kg of solid phase}}{\text{mg of solute/L of solution}}$$
 [Eq. 8-3]

Values of K_d will vary for each chemical with the composition of the sorbing media. Since the organic carbon content of the aquifer has a significant impact on sorption, K_d is commonly normalized for the amount of organic carbon in the soil (Karickhoff, Brown, and Scott 1979) such that:

$$K_d = K_{oc}f_{oc}$$
, where f_{oc} = the fraction of organic carbon in the soil. [Eq. 8-4]

Although this K_d equation is generally applicable to organic chemicals, more precise relationships have been developed for an individual chemical or class of chemicals under specific conditions. Schnellenberg, Leuenberger, and Schwarzenbach (1984) have derived a relationship between the F_{oc} , K_{ow} , and K_d for chlorinated phenols where:

$$Kd = (F_{oc})(b)(K_{ow})a$$
 [Eq. 8-5]

Where a = 0.82 and b = 1.05, derived for chlorophenols by Schnellenberg, Leuenberger, and Schwarzenbach (1984). This relationship applies only to the nonionized phenols.

When no solute is sorbed to the solid phase, the K_d is equal to zero, and it is assumed that the chemical would move at the same speed as the groundwater. The K_d is used to determine the retardation (R) of a chemical with a linear equilibrium partitioning in the groundwater where:

$$R = \frac{\text{Time for retarded chemical to reach a given point}}{\text{Time for groundwater (or nonsorbing chemical) to reach a given point}}$$
 [Eq. 8-6]

R can be measured as:

$$R = 1 + \frac{(\text{soil bulk density})(K_d)}{\text{total porosity}}$$
 [Eq. 8-7]

The retardation coefficient provides an idea of the ability of a contaminant to be transported. A value of 1.0 indicates that the contaminant is nonreactive and may be transported readily, as in the groundwater. A value greater than 1.0 indicates that the contaminant transport will be slowed by retardation processes. Typically TCE (chlorinated hydrocarbons) have R values of 3 to 6 and are fairly mobile, while dioxins have R values of > 100 and are essentially immobile.

8.2.4 Transformation Reactions

Transformation or removal of contaminants in the subsurface can occur through the actions of microorganisms, which are present or introduced into an environment.

PCDDs/PCDFs have exhibited relatively strong resistance to microbial degradation in soils (Freeman and Schroy 1984; Matsumura and Benezet 1973). The compound 2,3,7,8-TCDD is susceptible to photolysis but is generally resistant to other chemical degradation. The environmental significance of 2,3,7,8-TCDD photolysis has not been well documented. Several studies have reported that photolysis is the primary mechanism of TCDD degradation, and that, under some conditions, no other degradation would occur (Young, Kang, and Shepard 1983; DiDomenico and Vivano 1982).

Aromatic hydrocarbons can be biologically transformed in some soils and sediments (Barker, Patrick, and Major 1987); the rate and extent of transformation is highly dependent on site-specific factors such as temperature, pH, and the microbial composition of the soil. Ethylbenzene, toluene, and xylenes undergo oxidative degradation under aerobic conditions. Verschueren (1983) and Wilson *et al.* (1986) have recently shown that these compounds can also undergo reductive decomposition under anaerobic, methanogenic conditions.

Daughter products of TCE consistent with the anoxic reductive dehalogenation transformation process shown in Figure 8-2 have been detected in some of the OU-4 groundwater samples, and may indicate actual contaminant transformation conditions. Figure 8-2 conceptually shows the schematic breakdown and transformation of a chlorinated hydrocarbon and what and how daughter products are formed.

PAHs have been found to biodegrade in soil (Howard 1989). But, high initial PAH source concentrations and/or lack of oxygen will negatively impact aerobic microbial degradation which could prolong the existence of PAHs in the source areas.

Organochlorine pesticides have been found to be highly resistant to chemical and biological transformation and may be present in source areas for an undetermined amount of time (EPA 1979; Sayler, Shon, and Colwell 1977). However, chemical and biochemical reactions affect transformations of pesticides, resulting in molecular alterations and in degradation down to complete mineralization (Mansour 1993).

8.3 CONTAMINANT MIGRATION ROUTES

Inorganic and organic contamination identified at each of the sources exhibits many of the properties discussed in the previous sections. Site-specific conditions that may further influence contaminant migration are discussed in the following sections.

8.3.1 Landfill Source Area

The organic compound contamination identified at the Landfill is located predominantly in groundwater. Inorganic elements that are considered contaminants are located primarily in the ash cover of the Landfill. Contaminant migration pathways available at the Landfill include:

- Continued infiltration of contaminants from unidentified Landfill sources through unsaturated subsurface soils to the groundwater;
- Volatilization of contaminants within the vadose zone or partitioning of contaminants from groundwater at the interface;
- Ash transport via wind erosional mechanisms;
- Ash and continued sediment transport via moving water in drainage ditches to surface water bodies and the Chena River;
- Migration of contaminants along the groundwater interface (the active layer present between the surface and top of permafrost);
- Migration of contaminants through preferential pathways in the permafrost (talik zones) in the saturated zone via advection and dispersion; and
- Density driven groundwater flow of dissolved DNAPLs.

Contaminant transport mechanisms are discussed in the following sections.

8.3.1.1 Surface Water

Surface water is one of the primary transport mechanisms for contaminants at the surface of the Landfill to migrate off-site, especially during the spring breakup period. It is expected that surface water transport will not be a factor during the winter months when much of the site is frozen or covered with snow. Contaminant migration via surface water is not expected to be a pathway of concern at the Former Trench Area since all potential contaminants were buried and the area is vegetated. The Landfill is elevated an average of 20 feet above the natural grade at its highest point in the northern portion and slopes gradually toward the south. The area immediately around the Landfill is fairly level. Surface water runoff is likely to pool in the wetlands surrounding the Landfill on the north, west, and east sides of the Landfill or flow into the drainages to the southwest and southeast corners of the Landfill and directly south of the Landfill. The drainages extend southward, are culverted under River Road, and eventually drain to the Chena River. Surface water may also flow via the drainages from the Landfill to the gravel pit areas located southwest and south of the Landfill. Contaminants are likely transported by surface waters either as a sheen, in a dissolved form, or as particulates that are suspended or hydraulically transported along the drainages.

Ash may be transported by surface water either as a suspended solid or as larger solids transported hydraulically along the bottom and sides of the drainages. Ash transport via wind erosion and saltation also may be a transport mechanism at the Landfill. Ash is only available to transport via this mechanism when exposed, as the Landfill is covered by snow for the remainder of the year.

Inorganic and organic compounds, such as metals, petroleum hydrocarbons, PAHs, and pesticides will sorb onto sediments and be transported in runoff.

8.3.1.2 Groundwater

Contaminant migration in groundwater is dependent on numerous factors. These include the physical and chemical characteristics of the contaminant, the subsurface lithology, the groundwater gradient and the aquifer's characteristics, and permafrost. The geophysical surveys and lithologic borings completed at the Landfill indicate that permafrost is present

discontinuously over the Landfill area. At locations where it is encountered, permafrost influences the movement of groundwater both within the active layer (suprapermafrost aquifer) during the summer months and in the saturated zone all year (intrapermafrost aquifer). Contaminant transport in the active layer probably occurs well after the spring breakup, when thawing can extend to the permafrost depth, until the first freeze of the fall, when freezing of the active layer prevents any movement. Lithology within the active layer also may contribute to contaminant movement either to channel contaminants or to inhibit their migration. Contaminant transport in the saturated zone likely occurs within talik (unfrozen) zones identified during the site characterization and near and beneath surface water bodies. Contaminants detected at the Landfill include petroleum hydrocarbons or fuel-related compounds and exhibit LNAPL characteristics. Petroleum hydrocarbons detected in many of the wells at the Landfill may represent wide spread low level contamination by petroleum contaminants. LNAPLs will primarily be within the active layer and through talik zones in the subsurface permafrost where it exists.

Dissolved contaminants that are denser than water (DNAPLs) exhibit unique transport properties. After moving through the unsaturated zone and reaching the groundwater interface or permafrost, DNAPLs sink through the saturated zone as a separate phase, if present as product, or dissolve into the groundwater. If permafrost is present they may pool. The contaminants then sink through the aquifers to bedrock or permafrost, while continuing to migrate with the regional groundwater flow. Groundwater samples collected from AP-5588, AP-5589, AP-6137, and AP-6138 indicate that concentrations of contaminants are lower at the deeper of the well pairs. However, the concentrations of DNAPLs detected do not indicate the presence of a free product source. The contaminants detected in these wells appear to be following the transformations outlined for a PCA source depicted in Figure 8-2. The contamination within the drainage area transport pathway appears to be migrating from a potential source area in the southwest part of the Landfill to the southwest drainage. Chlorinated hydrocarbons have not been detected in AP-6139 located near River Road and downgradient of AP-5588/5589 and AP-6137/6138, and concentrations of detected compounds decrease away from the potential source area (i.e., AP-5588/5589). This may indicate that permafrost or other geologic controls are retarding the flow of contaminants or the short time available during the summer season for transport within the active layer aquifer through the drainage. Significant dilution effects also may be taking place. Biodegradation and transformation of the contaminants also appear to be occurring on the basis of daughter products detected.

8.3.2 Coal Storage Yard Source Area

Contamination identified at the CSY consisted primarily of fuel-related volatile organics (i.e., BTEX) and chlorinated hydrocarbons, and was characterized primarily in subsurface soils and groundwater beneath the active coal pile. The mechanisms of contaminant transport for the subsurface soils and groundwater are discussed below.

8.3.2.1 Subsurface Soils

Subsurface soil contamination has likely migrated through existing soil pore spaces to the extent that capillary forces and partitioning have exceeded the gravitational influence. Further migration of the contamination on its own is not expected to occur because of the concentrations detected in the soils and the apparent lack of a contaminant product within the interstices of the soil. However, the soil contamination is subject to further downward migration augmented by precipitation and the expected infiltration of water from rainfall or snow melt. Solubility of the contaminants makes them subject to further migration via infiltration. This mechanism may be slowed somewhat by the coal pile which may absorb some of the precipitation.

Ambient groundwater temperatures in the area of the CSY from plant operations also are a factor in contaminant transport. With groundwater temperatures averaging 25°C (see Figure 6-3a) approximately 20°C higher than other areas at Fort Wainwright (i.e., FTPs), volatilization is a likely transport mechanism. Heat rising from the groundwater elevates temperatures in upper soils within the vadose zone. The active coal pile also acts as an insulator, particularly during the winter months, to limit the amount of heat loss to the atmosphere. This heat likely influences the degree to which volatilization occurs. Volatilized contaminants probably remain in the pore spaces of the vadose zone or escape to the atmosphere. This mechanism may occur to a greater degree in the area adjacent to the coal pile where the contaminant source is located until contaminants reach the groundwater and become influenced by groundwater movement.

8.3.2.2 Groundwater

Contaminants at the groundwater interface are dissolved or get carried as floating product. These contaminants are likely to be the gasoline (i.e., BTEX) or fuel-related compounds exhibiting LNAPL characteristics. Elevated groundwater temperatures (i.e., 25°C) likely continue to volatilize contaminants until "cooler" groundwater temperatures are encountered away from the influence of the cooling pond. LNAPL or dissolved contamination was not detected in the surrounding wells or Geoprobe®/MicroWell locations north of the coal pile.

Contaminants in groundwater (specifically chlorinated compounds such as TCE) exhibit DNAPL properties. After reaching the groundwater interface, DNAPLs sink through the saturated zone as a separate phase, if present as a product, or dissolve in the groundwater. Groundwater temperatures in the CSY area increase the likelihood of dissolution, as compared to other areas at Fort Wainwright. Contaminants, dissolved or DNAPLs sink through the aquifer to bedrock or migrate with the regional groundwater flow as the contaminants migrate past the influences of the groundwater interface flow. Groundwater samples collected at discrete depths indicate a general decrease in concentration of contaminants to an approximate depth of 80 feet BGS. Contaminants were not detected at the depths of 90 and 100 feet BGS. Concentrations detected do not indicate the presence of DNAPLs or the former existence of DNAPLs.

Contaminants characterized within the saturated zone are subject to further migration either to the north via the water table flow or to the west via the regional flow at depth. Fuel related contaminants (i.e., BTEX) are likely to be more influenced by the water table flow because they would float as LNAPLs or as dissolved contaminants. The chlorinated compounds are likely to migrate downward and enter depths at which the regional flow would influence further movement. Downward migration would only occur if the chlorinated compounds had not volatilized from the relatively higher ambient temperature influenced by the cooling pond.

Based on existing data, the effect of elevated groundwater temperatures on contamination in the groundwater cannot be determined. There is likely a depth in the cooling pond area at which the influence of heated water is minimal compared to the regional groundwater temperature. The heated groundwater influenced by the cooling pond may have limited effect at depth. As contaminants migrate through the saturated zone and encounter cooler groundwater at depth, water density differences also influence further migration.

Downgradient monitoring wells, Geoprobe groundwater samples, and Microwell groundwater samples at depth indicated there is no groundwater contamination downgradient (i.e., northerly or westerly) at the groundwater table or at deeper intervals of the aquifer. It is suspected that contaminants are volatilized before significant groundwater migration takes effect, or groundwater movement has acted to dilute and disperse contaminants, or a combination of the two.

8.3.3 Fire Training Pits Source Area

Contamination identified at the FTPs consisted primarily of fuel-related volatile organics (i.e., BTEX) and chlorinated hydrocarbons, and was characterized primarily in surface soils and groundwater. The mechanisms of contaminant transport for the soils and groundwater are discussed below.

8.3.3.1 Surface Soils and Sediment

Migration of contaminants via runoff from precipitation and snowmelt is a potential mechanism for off-site transport of surficial contamination at the FTPs. However, the relatively flat topography in the vicinity of the FTPs and the permeable nature of surface soils preclude overland transport of contaminants over significant distances. Several drainage ditches and isolated wetlands exist in the general vicinity of the source area. During periods of high runoff (i.e. spring break-up), contaminants bound to soil particles and sediments are probably transported to these ditches and wetlands. These features are sinks (migration endpoints) for these contaminants; further migration from the general vicinity of the FTPs is not expected to occur due the relatively high affinity for the detected soil contaminants (i.e. metals, dioxin, long-chain hydrocarbons) to bind to soil particles and organic matter, and the flat topography discussed above. Although the ditch located north of the FTPs is in close proximity to surface contamination detected during the RI, significant off-site migration via this drainage feature to Chena River is unlikely because of distance to the river from the FTPs (approximately 2 miles).

Additional potential transport mechanisms for surficial contamination at the FTPs include leaching into subsurface soils to groundwater, natural degradation of the contaminants

in-place, and transport in air as particulates. The relatively high organic content of the soils in the vicinity of the FTPs tends to inhibit significant vertical migration of contaminants through the vadose zone. Natural biological and physical degradation of the contaminants at the FTPs, especially the petroleum-related and VOCs, reduces contaminant concentrations in surface soils through time. Contaminants bound to fine soil particles may be transported as particulates in air during dry windy periods, for those limited areas that are not covered with vegetation. The presence of trees surrounding the FTPs is expected to inhibit particulate transport of contaminants over significant distances, and the six- to eight-month snow cover in the Fort Wainwright area reduces the time in which particulate transport of surficial contaminants can occur.

8.3.3.2 Subsurface Soil

As discussed above, the migration of contaminants through the vadose zone is not anticipated to be a major migration mechanism for contaminants at the FTPs. This is supported by the RI results, presented in Section 7.2, that indicate relatively few COPCs are present in subsurface soils underlying the site. VOCs in groundwater underlying the site could, however, migrate (i.e., volatilize) vertically upward through the vadose zone to the surface. Although vertical migration of VOCs through the vadose zone is a potential migration mechanism, evidence of this was not observed in subsurface soil samples collected for the RI, nor were VOCs present at sufficient concentrations in the groundwater that volatilization is likely. If volatilization occurred, the medium-to coarse-grained soils at the FTPs would be conducive to this form of volatile transport.

8.3.3.3 Groundwater

Contamination in groundwater underlying the FTPs is migrating west-northwest (see Section 7.1) with the regional groundwater flow. Migration of dissolved contaminants in groundwater is expected to be primarily horizontal; however, hydraulic gradients measured in the vicinity of the FTPs during the RI suggest that dissolved chemical contaminants may be influenced by upward hydraulic gradients. The vertical gradients measured at the FTPs Source Area may contribute to increased dispersion and dilution of dissolved contaminants. An additional potential factor affecting dispersion of contaminants in groundwater is the presence of several DNAPLs, including TCE and chlorinated alkane, which may have the

tendency to migrate vertically downward through the aquifer because of their solubility and density properties. The absence of a defined, concentrated contaminant plume downgradient of the FTPs Source Area suggests that dilution of contamination introduced to the aquifer from the FTP sources is occurring or has occurred. Further contaminant migration in groundwater is not limited because of the apparent lack of low relative permeability zones in the aquifer.

Table 8-1

PHYSICAL AND CHEMICAL PROPERTIES OF PRIMARY ORGANIC CHEMICALS OF POTENTIAL CONCERN OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Chemical Name	CAS Number	Mole Weight (g/mole)	Physical State at 20°C	Water Solubility (mg/L)	Source	Liquid Density (g/mL)	Source	Vapor Pressure (mm Hg)	Source	Henry's Law Constant (ahm-m ³ /mol)	Source	K _{oe} (mL/g)	Source	Log K _{oc}	Source	ВСГ	Bource
VOCs .																	
1,2-Dichloroethene (Total)	540-59-0	97.0	Liquid	3.50 E+03	۸	1.28	В	208	С	7.58 E-03	D	49	С				
Tetrachloroethane	127-18-4	165.8	Liquid	1.50 E+03	A	1.63	В	18.5	A	2.59 E-02	۸	118	С				
Trichloroethene	79-01-6	131.4	Liquid	1.10 E+03	۸	1.47	В	72.9	A	9.1 E-03	D	126	С				
Aromatic Hydrocarboni																	
Ethylbenzene	100-41-4	106.2	Liquid	1.61 E+02	A	0.86	I	9.53 E+00	A	8.44 E-03	A	1.10 E+03	A	3.15	A	37.5	E
Toluene	108-88-3	92.1	Liquid	5.35 E+02	A	0.87	В	28.1	A	5.94 E-03	A	300	С	2.73	A	26	E
Xylenes	1330-20-7	106.2	Liquid	1.60 E+02	A	0.86	В	10	۸	6.82 E-03	A	240	С	3.20	н	70	E
Dioxins/Furans																	
2,3,7,8-TCDD	1746-02-6	322.0	Solid	2.00 E-04	l	1.83	G	1.70 E-06	i	3.60 E-03	Į.	3.30 E+06	1	6.20	G	5.00 E+03	I
Organochlorine Pesticid	les																
4,4'DDT	50-29-3	354.5	Solid	5.00 E-03	I	2.50 E-05		2.50 E-05	F	5.13 E-04	F	2.43 E+05	ī	6.36	E	5.40 E+04	1
4,4'DDE	72-55-9	319.03	Soid	4.00 E-02	G	_	G	6.49 E-06	G	2.34 E-05	G	2.43 E+05	G	5.77	G	1.57 E+04	I
Polynuciear Aromatic I	iydrocarbons																
Benzo(a)anthracene	56-55-3	228.30	Solid	1.20 E-02	G	1.27	G	2.20 E-08	G	2.30 E-06	G	1.38 E+06	G	5.90	G	1.17 E+04	1
Benzo(a)pyrene	50-32-8	252.32	Solid	390 E-03	G	1.35	G	5.60 E-09	G	2.40 E-06	G	1.00 E- 06	G	6.00	G	5.00 E+03	F
Benzo(b)fluoranthene	205-99-2	252.32	Solid	1.40 E-02	G	_	_	5.00 E-07	G	2.20 E-05	G	5.49 E+05	G	6.57	G	-	_

Key at end of table.

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Table 8-1

PHYSICAL AND CHEMICAL PROPERTIES OF PRIMARY ORGANIC CHEMICALS OF POTENTIAL CONCERN OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

Chemical Name	CAS Number	Mole Weight (g/mole)	Physical State at 20°C	Water Solubility (mg/L)	Source	Liquid Density (g/mL)	Source	Vapor Pressure (mm Hg)	Source	Henry's Law Constant (ahm-m³/mol)	Source	K _{oc} (mL/g)	Source	Log K _{oc}	Source	BCF	Source
Benzo(k)fluoranthene	207-08-0	252.32	Solid	5.50 E-04	G	_	-	9.59 E-11	G	1.04 E-03	G	4.36 E+06	G	6.85	G	_	_
Chrysono	218-01-9	228.30	Solid	1.80 E-03	G	1.27	G	6.30 E-09	G	7.26 E-20	G	2.45 E+05	G	5.61	G	-	_
Fluoranthene	206-44-0	202.0	Solid	2.06 E-01	I	1.27	_	5.00 E-06	1	6.46 E-06	I	3.80 E+04	1	4.90	С	1.15 E+03	I

- A) Howard, P., 1989, Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume I, Lewis Publishers, Inc.
- B) Weast, R., ed., 1983, Handbook of Chemistry and Physics, 63rd edition, CRC Press, Cincinnati, Ohio.
- C) Mabey, W., et al., 1982, Aquatic Fate Process Data for Organic Priority Pollutants.
- D) Mackay, D., and W. Shim, 1981, J. Phys. Chem. Ref. Data, 19:1175-1179.
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- F) Kitano, M., 1978, Biodegradation and Bioaccumulation Tests on Chemical Substances, OECD Tokyo Meeting, TSU-No. 3.
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- H) Mercer, J.W., 1990, Basics of Pump-and-Treat Groundwater Remediation Technology, EPA-600/8-90/003.
- I) Miscellaneous Physical Contract Handbooks.
- J) Smith, J.A., P.I. Wikowski, and T.V. Pasilo, 1988, Manmade Organic Compounds in the Surface Waters of the United States A Review of the Current Understanding, USGS Circular 17.

Key:

= No available data.

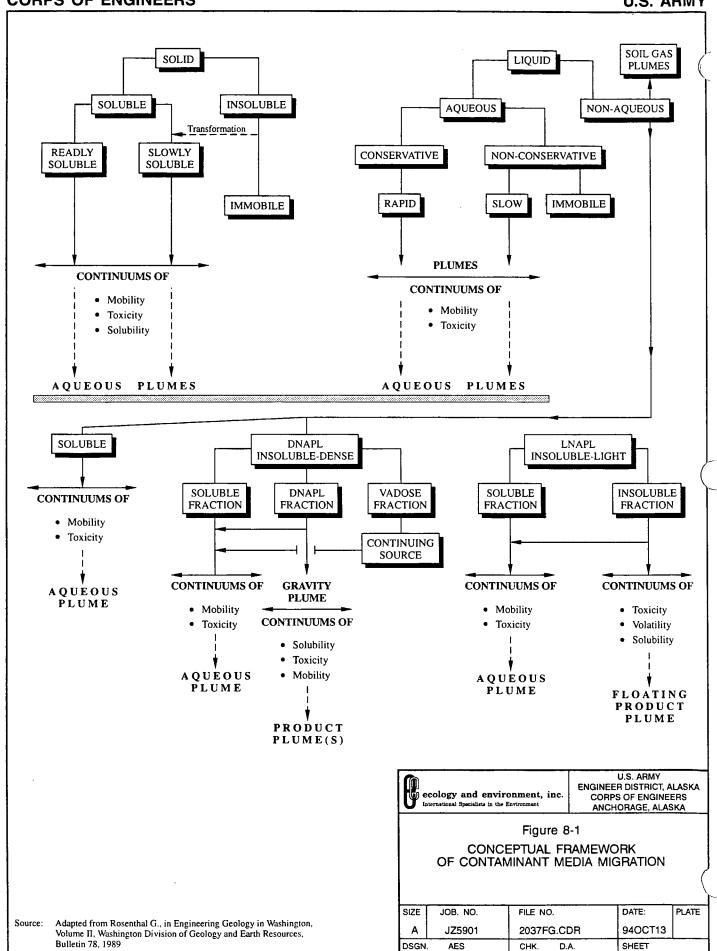
g/mL = Grams per liter.

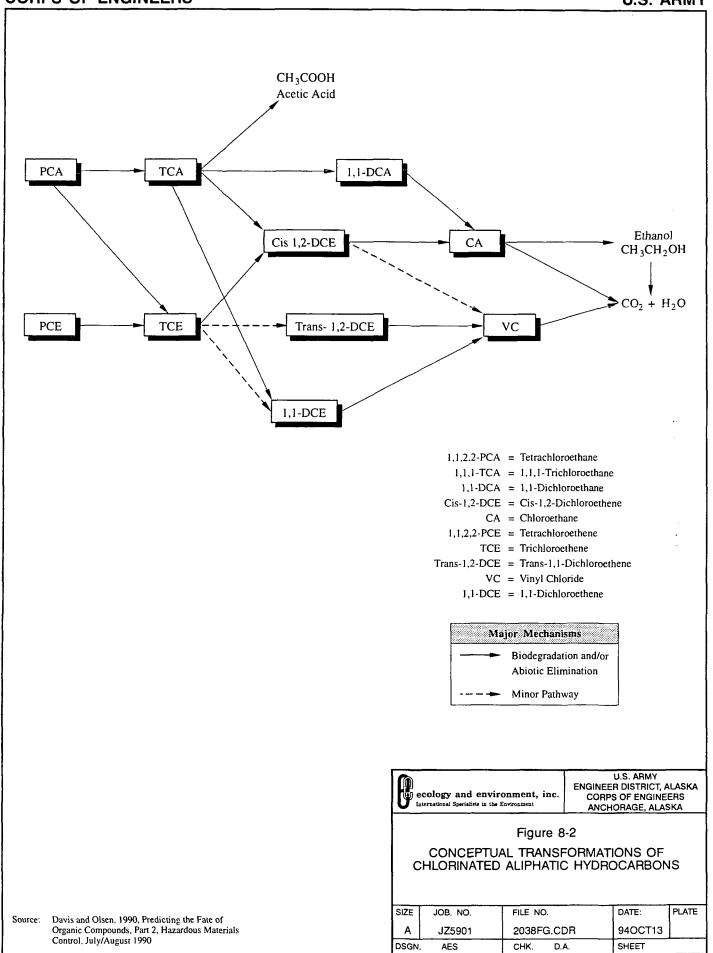
mg/L = Milligrams per liter.

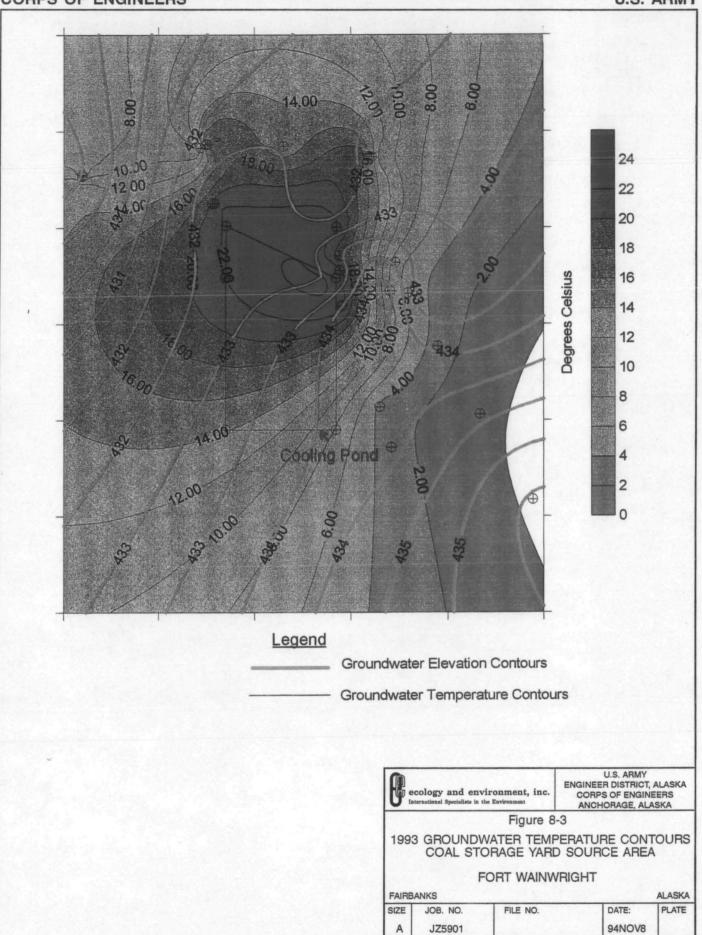
mL/g = Milliliters per gram.

mmHg = Millimeters of mercury.

VOCs = Volatile organic compounds.







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9. SUMMARY AND CONCLUSIONS

The RI conducted at Fort Wainwright to characterize the three sources areas (i.e., the Landfill, the CSY, and the FTPs) comprising OU-4 was completed during two separate field events. The first field event was conducted during September and October of 1993, and the second field event was conducted during May and July 1994. At the time of production of the draft RI report, some activities were still underway at the Landfill. These ongoing activities include sampling of three additional wells west of the Landfill. Analytical results from these groundwater samples will be available in December 1994. On the basis of data collected thus far, the following sections summarize the RI findings for each source area.

The overall conclusion drawn from the baseline HHRA is that the estimates of potential excess lifetime cancer risks and HIs are within or fall below the regulatory benchmarks defined by the EPA Superfund program under current land-use conditions. These current cancer and noncancer risk estimates are relatively low because complete exposure pathways do not exist (i.e., a current, complete exposure pathway does not exist for most groundwater at OU-4) and the concentrations of COPCs detected in other OU-4 environmental media are relatively low.

Potential cancer and noncancer risks in excess of regulatory guidelines were associated only with the hypothetical future domestic use of groundwater. As described in the baseline HHRA, this scenario was included for information purposes at the request of EPA and ADEC. The risk results derived from this evaluation will not necessarily be used to establish cleanup goals.

9.1 LANDFILL

Contamination at the Landfill Source Area, in the form of inorganic elements and chlorinated and petroleum hydrocarbon-related contaminants, was detected mainly in ash covering the active Landfill Area, in the drainages surrounding the Landfill and in groundwater. No contamination was identified at the former trench area south of River Road. A brief summary of the contamination and assessment of migration potential are provided below.

9.1.1 Contaminants of Potential Concern Detected

COPCs identified at the Landfill include inorganic elements, petroleum and chlorinated hydrocarbons, dioxins, and pesticides that were located predominantly in ash, surface soils, sediments, and groundwater. Inorganic elements that are considered COPCs were identified in surface soils, ash, sediments, and groundwater. Table 9-1 presents the COPCs for the Landfill by media.

9.1.2 Distribution of Contamination

Surface soil, sediment, and ash contamination appeared to be primarily limited to the active Landfill Area; however, some contaminants were detected along drainages and surface water bodies surrounding the Landfill. The drainages run from the Landfill to standing bodies of surface water and wetlands, or the Chena River.

Pesticides detected at the Landfill were concentrated in the drainages and surface water bodies north, south, southwest, and southeast of the Landfill. Surface ash samples containing dioxin/furan congeners were mainly collected from the active Landfill Area and are likely the result of burning coal at the power plant. Samples containing metals were collected from the active Landfill Area and surface soil and sediment in the drainages. The higher concentrations found in surface soil samples from outside the active Landfill Area are likely unrelated to Landfill operations. Elevated metals concentrations detected in the drainages were likely related to runoff and transport of soil and rock constituents. Organic petroleum hydrocarbon contamination was detected mainly in samples from drainages and surface water bodies around the Landfill.

No organic or inorganic contamination was detected in subsurface soils at the Landfill above established background levels, MCLs, or RBCs.

Groundwater organic contamination appeared to be limited to hot-spots along transport pathways generally located within the drainages and beneath surface water bodies surrounding the Landfill. Inorganic elements detected in groundwater are predominantly associated with naturally occurring concentrations for the Fairbanks area, and are likely not associated with contamination from the Landfill. As with surrounding areas at Fort Wainwright area, the higher inorganic concentrations detected in wells at the Landfill are the result of a combination of hydrogeochemical processes associated with the proximity of the Birch Hill schist, the presence of permafrost, and the limited groundwater movement within permafrost areas.

Organic contamination, particularly chlorinated hydrocarbon contamination, was detected in two previously existing wells (AP-5588 and AP-5589) and a single well installed in 1993 at the Landfill (AP-6137). The wells are located in the southwest drainage area, which is suspected to be the preferential transport pathway southwest of the Landfill. Other locations with identified organic contamination appear to be isolated occurrences (i.e., hotspots) with no discernable pattern of distribution.

9.1.3 Expected Migration Pathways

Surface water is one of the primary transport mechanisms for contaminants identified in surface soil, sediment, and ash at the Landfill Source Area. This pathway is expected only to be important during the spring breakup period and the summer months. Surface water transport is not expected to be a factor during the winter months when much of the site is frozen or covered with snow. However, the freeze-and-thaw process occurring within the active layer and its effect on contaminants in the soil have not been investigated. Surface water runoff is likely to pool in the wetlands to the north, west, and east of the Landfill or flow into drainages to the southwest and southeast corners and directly south of the Landfill. The drainages lead southward and eventually drain to the Chena River or to the gravel pit areas located southwest and south of the Landfill.

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Prior to conducting RI activities at the Landfill, chlorinated compounds were detected consistently at two wells installed along the west edge of the fill area (i.e., AP-5588 and AP-5589). Samples collected from these wells during both phases of the RI work confirmed the presence of the chlorinated compounds and other wells installed and sampled did not

delineate a plume of contamination but did detect contamination downgradient of AP-5588 and AP-5589.

Extensive geophysical work has been completed in the Landfill Source Area and adjacent areas by CRREL and E & E. The results indicate that the top of permafrost, as well as the bottom of permafrost, to some extent, is variable with top of permafrost varying over a broad area and no permafrost occurring in other areas. CRREL's interpretations suggest patterns analogous to remnant stream channel scars. Lithology and groundwater movement may be factors in creating these undulations. The geophysical results suggest that a thaw bulb exists beneath the Landfill, but unlike the narrow channels suggested by CRREL in other areas, the thaw bulb more likely exists over a broad area roughly matching the area of the Landfill, based on the geophysical data obtained. Thawing of the area likely is a result of the removal of insulating trees and vegetation at the time of the Landfill construction and heat generated by the decomposing refuse. Geophysical sounding data could not confirm the presence of permafrost at depth directly beneath the Landfill; however, layered model solutions for some of the sounding data appeared to match a thaw bulb scenario with permafrost occurring at depth. Permafrost has been characterized to exist to bedrock along the west edge of the Landfill, except along the southwest and southeast drainage. If geophysical interpretations are in error with regard to a thaw bulb beneath the Landfill, and no permafrost exists beneath the Landfill, permafrost still occurs at depth to bedrock in surrounding areas as characterized in the boreholes and cross sections. This would still provide a limited area for contaminants to migrate, except along drainages. This scenario would limit the migration of contaminants to drainages already characterized. The general pathways would likely be along the bedrock interface until the influences of the regional groundwater flow at depth took effect.

Groundwater transport in the active layer likely occurs after the spring breakup until the first freeze of the fall, when freezing of the active layer prevents or retards any movement. The active layer in the Landfill appears to be approximately 5 to 7 feet thick. Groundwater transport in the saturated zone occurs within unfrozen talik zones identified in the drainage areas southwest of the Landfill.

LNAPL contaminants are mainly transported within the active layer and as dissolved components through talik zones in the subsurface permafrost where it exists. LNAPL contamination does not appear to be widespread at the Landfill Source Area.

DNAPLs move through the unsaturated zone and reach the groundwater interface or permafrost. Chlorinated hydrocarbon concentrations detected during the RI suggest that no free product exists but soil contaminants in contact with groundwater partition as dissolved groundwater components. The dissolved contaminants then migrate with the regional groundwater flow and possibly sink through the aquifers to bedrock, permafrost, or other fine-grained units.

Groundwater movement at the Landfill, as contoured water elevations indicate, likely is complex where permafrost exists and varies in thickness and depth. CRREL geophysical and boring data (CRREL 1995) also suggest a complex interaction of groundwater flow patterns in the east, north, and west areas, where permafrost exists. Along the southwest drainage area, where contamination was identified, groundwater flow was determined to be southwest in the general direction of the surface drainage pathway. In this area where permafrost is absent, groundwater movement will be influenced more by the regional groundwater flow and the Chena River flow system.

9.2 COAL STORAGE YARD

Contamination at the CSY occurs mainly beneath the active coal pile in subsurface soils and groundwater in the form of chlorinated and petroleum hydrocarbon-related contaminants. A brief summary of the contamination and assessment of migration potential are provided below.

9.2.1 COPCs Detected

Contaminants of concern for the CSY consist of inorganic elements, petroleum, and chlorinated hydrocarbons in soils and groundwater. Table 9-2 lists the contaminants detected in soil and groundwater samples collected at the CSY.

9.2.2 Distribution of Contamination

In general, inorganic contamination in all soil and sediments followed no definable pattern or plume. Elements defined as COPCs occurred at a wide range of values above and below RBCs. Inorganic contamination, except manganese, in surface and subsurface soil was randomly distributed with hot-spots in surface and subsurface soil at AP-6159 located south of the emergency coal pile and in surface soil at AP-6162 located north of the fenced storage

yard. High manganese concentrations in surface and subsurface soil were predominantly near or under the coal piles. In sediments, concentrations detected above the RBC occurred in isolated sediment samples in the cooling pond and at isolated locations outside of the coal pile area. The sediment sample locations at the north end of the cooling pond (SD-5) and along the west bank (SD-9) exhibited the highest concentrations of chromium, mercury, and copper. These contaminants may be related to wood preservative products used on access docks for the cooling pond contamination levels found in sediments collected outside of the cooling pond are similar to those found in surface soil. In contrast to soil and sediments in which contamination was randomly distributed, inorganic contamination in groundwater is predominantly found in wells adjacent to the cooling pond. The heat of the water in the cooling pond may effect nearby groundwater by increasing the solubility of certain elements. Past practices have also included using a copper sulpriate compound to control weed growth in the cooling pond. No other compounds or additives to cooling water were used in the cooling pond or in the piping supplying a cooling water to the power plant.

Petroleum-related contamination is in all media at the CSY. All surface soil contained Bunker C-range organics, including background samples. However, petroleum-related contamination in surface and subsurface soil in excess of all State of Alaska cleanup levels were only identified within the area of the coal pile and the fenced storage yard.

BTEX and chlorinated hydrocarbon contaminated soils were also present in subsurface soil under the coal pile. The volume of contaminated soil lies within the immediate vicinity of the coal pile, which exhibited none or greatly reduced levels of TRPH contamination; is estimated to be 380 by 310 feet. Depth to groundwater is approximately 15 feet BGS. Petroleum contamination identified near the fenced storage yard is not considered in the above volume estimates. The highest diesel concentration for samples from this area was 360 mg/kg, which exceeds the State of Alaska Cleanup Levels A and B. Subsurface soil contamination may be related to the UST within the fenced storage yard or to the application of fuels and solvents to the coal pile. Since soil borings located between the coal pile and drum storage area exhibited petroleum contamination (i.e., low level TRPH, diesel, and bunker C-range organics) in subsurface soils, a distinction between the areas cannot be made.

Sediment samples, particularly in the cooling pond, indicated the presence of TRPH bunker C-range organics, diesel, and DRO. No sediment exceeded the State of Alaska Cleanup Levels for non-UST contaminated soils. The bottom of the cooling pond consists of

prolific rooted aquatic plants. This suggests that accumulation of contaminants at their present levels has not impacted the vegetation.

Petroleum contamination in groundwater extends from the background well at the corner of Alder and Meridian Roads to the wells north of the power plant and west of the cooling pond. The widespread distribution of this contamination suggest that the origin of the contamination is not exclusively from practices at the CSY.

Chlorinated hydrocarbon in groundwater contamination appears to be limited laterally to the area under the active coal pile and fenced storage yard, based on monitoring well, Geoprobe[™], and MicroWell groundwater samples. In addition to contamination at the groundwater interface, contamination was characterized at depth beneath the coal pile. TCE (9.7 µg/L) was detected at a depth of 80 feet BGS. BTEX was detected at 90 and 100 feet BGS, but TCE was not. TCE contamination identified in the drum storage area at monitoring wells 3595-01 and 3595-02, but does not appear to follow an identifiable plume. Chlorinated hydrocarbon contamination in groundwater could have originated from waste fuel application to the coal pile, which then migrated east through the subsurface soils. The contamination also could be related to the USTs in the fenced storage yard, where fuels and solvents were stored and then applied to the coal pile, if the USTs leaked. According to DPN, (1995) the USTs are scheduled for removal prior to any remedial action at the CSY.

9.2.3 Expected Migration Pathways

Further migration of subsurface soil contamination is likely by infiltration of precipitation (i.e., snowmelt or rainfall).

Ambient groundwater temperatures in the area of the CSY from plant operations is a factor in contaminant transport. With groundwater temperatures averaging 25°C at wells adjacent to the cooling pond, volatilization is a likely transport mechanism. Heat rising from the groundwater would elevate temperatures in upper soils within the vadose zone, inducing volatilization of contaminants remaining in the soils.

Contaminants at the groundwater interface dissolve or are carried as floating product. Elevated groundwater temperatures (i.e., 25°C) likely would continue to volatilize contaminants until "cooler" groundwater temperatures are encountered away from the influence of the cooling pond. Contaminants in the groundwater exhibiting DNAPL properties (i.e., TCE)

sink and migrate with the groundwater flow. Groundwater temperatures in the CSY area would increase the likelihood of dissolution, until cooler temperatures at depth are reached.

Groundwater movement in the active coal pile area is in a northerly direction by monitoring well elevations during the RI. It has been conjectured that the cooling pond generates a localized recharge area from runoff through culverts into the pond. This recharge may have an influence on the flow direction at the water table, at least during periods where the cooling pond is receiving a net gain (i.e., runoff). Continuous groundwater monitoring was conducted in the drum storage area by CRREL (1994). This monitoring also indicated a northwest groundwater flow but identified flow fluctuation to the northeast in response to pumping at well 3592. Use of this well is reportedly intermittent, but apparently has a significant impact on groundwater flow within the area when it is used.

The six additional wells (AP-6518, AP-6519, AP-6520, AP-6521, AP-6522, and AP-6523) installed in 1994 are intended to serve as monitoring points between the source area groundwater contamination and the water supply wells. These wells have been completed at the water table and at depths equivalent to the water supply well intakes. Groundwater monitoring of these wells should be conducted on a regular basis until the groundwater contamination no longer poses a threat.

9.3 FIRE TRAINING PITS

Contamination at the FTPs occurs in surface soil, subsurface soil, sediment and groundwater. Petroleum contamination was also detected in a background well. A summary of the COPCs identified and assessment of the migration potential are provided below.

9.3.1 COPCs Detected

Contaminant groups detected during the RI at the FTP Source Area include inorganic elements, chlorinated and non-chlorinated VOCs, petroleum hydrocarbons, dioxin/furan congeners, and pesticides. Impacted media include surface soil, sediments, subsurface soil, and groundwater as indicated in Table 9-3.

9.3.2 Distribution of Contamination

Surface soil contamination is identified primarily within the actual FTPs designated as FTP-3A and FTP-3B. The areal extent of the surficial contamination has not been completely

delineated based on the RI field activities sampling and detected compounds at the sampling locations; however, the nature of operations conducted at the sites suggest that contamination is restricted to the stained areas comprising each FTP. The surface area of known contamination at FTP-3A is estimated at approximately 100,000 square feet (approximately 2.3 acres). The surface area of known contamination at FTP-3B is estimated at approximately 16,000 square feet (approximately 0.4 acre). The small areas identified but not delineated can be delineated approximately during a remedial action by concurrent sampling and analysis.

Subsurface soil contamination is not widespread. The most significant subsurface soil contamination underlies FTP-3A, FTP-3B, and the depression north of the access area. The extent of the subsurface soil contamination has not been fully delineated; however, the RI results suggest that subsurface soil contamination occurs as localized areas in the soil column. Contamination at FTP-3A extends from the ground surface through the vadose zone to the groundwater and soil interface.

Sediment contamination is present in isolated locations surrounding the FTPs. The distribution of contamination characterized during the RI indicates that several hot-spots exist in the wetlands and drainage ditches. This is probably the result of surface runoff carrying contaminants from the FTPs to low points in drainage pathways, and the subsequent concentration of these contaminants in the sediment matrix over time or isolated spills resulting from military activities in these areas. Areawide spacial trends of contaminant distribution in sediment are not readily apparent from the analytical data generated and, therefore, estimates of contaminated sediment volumes are not available at this time.

Groundwater contamination is present throughout the FTP Source Area. The presence of VOCs and petroleum contaminants in the upgradient monitoring wells suggests that another contaminant source may be contributing to this contamination. Although a defined groundwater contaminant plume is not apparent from the RI data, a zone of contamination extending from AP-6147 in the southeast corner of the source area, to AP-6157 in the northwest corner of the source area is suggested. Monitoring well AP-6175 is assumed to delineate the northeastern boundary of this zone of contamination. If a contaminant plume exists, groundwater gradient information generated during the RI indicates the leading edge should be located northwest of the FTP-3A cleared area; however, the downgradient distance of the plume edge, if present, is unknown.

9.3.3 Expected Migration Pathways

Contaminant migration from the FTP Source Area is most likely through groundwater. Contaminated groundwater underlying the site will migrate with the local hydraulic gradient to the west-northwest. The downgradient extent that dissolved contaminants originating from the FTPs or from other upgradient sources have migrated downgradient has not been characterized. Based on the data, contaminated groundwater apparently may extend at least to the downgradient wells installed at the source area. It is believed that the petroleum and groundwater contamination is related to an upgradient source unrelated to the FTPs, based on similar compounds detected in background (upgradient) wells.

Additional mechanisms for contaminant migration from the FTPs include surface runoff, percolation through subsurface soil, and particulate transport of contaminants present in subsurface soils. Due to the flatness of the local topography, migration of contaminants by runoff is not expected to impact major surface water features in the Fort Wainwright area. Although leaching of contaminants through the surface to groundwater from precipitation is possible, results of subsurface soil sampling indicate that this is not a major migration mechanism because of the concentrations detected, except possibly at the FTP-3A area. Release of surficial contamination via air-borne particulates is not a major potential migration mechanism because this area is partially vegetated and there are long periods of snow cover in the Fort Wainwright area.

9.4 CONCLUSIONS

The following is a summary of the RI's major findings at each source area.

9.4.1 Landfill

- Concentrations of several inorganics in the ash cover of the landfill exceed background and RBCs.
- Aluminum, manganese, and vanadium appear to be more concentrated along topographic drainages than in the surrounding areas.
 However, barium concentrations did not exhibit the same trend, suggesting that barium is not migrating from the ash cover via surface runoff.
- Only one of eight ash sample locations exceeded RBCs for dioxin.

- Only one surface soil location west of the landfill exceeded the State of Alaska Matrix Cleanup Level for residual range petroleum hydrocarbons.
- No subsurface soil contamination was found at the landfill.
- Chlorinated hydrocarbons were detected consistently in monitoring wells AP-5588 and AP-5589 since their original installation in 1990 and during the RI. Only one downgradient wells (AP-6137) exhibited low levels of chlorinated hydrocarbons, indicating limited contaminant migration.
- Contaminants identified in well AP-6133 (i.e., bis(2-ethylhexyl)-phthalate, bromodichloromethane, and chloroform) were not confirmed during 1994 sampling because the well was frozen.
- Bis(2-ethylhexyl)phthalate was detected at seven wells in the southwest drainage area, with three wells not indicating contamination.
- Permafrost exists west, north, and east of the landfill. It may exist
 beneath the landfill at an unknown depth; however, geophysical
 results indicate a thawed region immediately below the landfill. The
 southwest drainage at the landfill was confirmed to be permafrostfree and is a suspected significant groundwater pathway.

9.4.2 Coal Storage Yard

- The highest inorganic contamination in surface and subsurface soils
 was found at locations south of the emergency coal pile and north of
 the fenced storage yard.
- Surface and subsurface soils beneath the active coal pile exceed the State of Alaska Matrix Cleanup Levels for benzene, BTEX, bunker C-range organics, and diesel; and exceed RBCs for chlorinated hydrocarbons.
- Subsurface soils in the fenced storage yard may be related to contamination originating at the active coal pile or the UST within the storage yard.
- High concentrations of inorganics and PAHs exist in the cooling pond's sediments. Variations in concentrations and distribution of this contamination may be related to water flow patterns generated by water circulation patterns from the power plant.
- Groundwater is contaminated with TRPH or bunker C-range organics in most of the wells sampled in 1993, including the background

- wells. In 1994, three wells contained petroleum related constituents at lower concentrations than found in 1993.
- High concentrations of BTEX and chlorinated hydrocarbons were identified in groundwater samples collected beneath the active coal pile from Geoprobe sample points and MicroWells.
- Dioxin concentrations in 1994 groundwater samples exceeded RBCs in 10 wells, including the background locations and well 119 located several hundred feet from Fort Wainwright's drinking water supply wells. However, the highest concentrations were detected in the background wells also corresponding to the highest turbidity. Samples results were "B" qualified (i.e., blank contamination) and none of the results exceeded MCL's..
- As indicated in the risk assessment, the excess lifetime cancer risks attributable to dioxin/furan congeners (i.e., expressed as 2,3,7,8-TCDD equivalents) were 1×10^{-3} at AP-5509, 5×10^{-6} at AP-5736, 8×10^{-7} at 3595-01, and 8×10^{-5} at 119.
- Manganese, iron, and antimony exceeded MCL's in five wells.
 Three of the wells are located along the east edge of the cooling pond. Heated cooling pond waters may be contributing to the higher concentrations of these metals.
- The groundwater flow direction within the active coal pile area is northerly and outside the active coal pile is northwesterly.
- Groundwater contamination was characterized at depth beneath the
 active coal pile. None of the six downgradient wells outside the coal
 pile area indicated groundwater contamination. The nearest water
 supply drinking water well (i.e., 119) is approximately 1,400 feet
 northwest and downgradient of the active coal pile area.
- Elevated groundwater temperatures from the power plant operation may contribute significantly to contaminant migration and volatilization.
- The effect of intermittent pumping from production well at the Power Plant may have an impact on groundwater flow and contaminant migration within in the CSY.

9.4.3 Fire Training Pits

 Elevated concentrations (i.e., greater than background and risk-based or screening concentrations) of inorganic elements including antimony, arsenic, barium, cadmium, and lead) were observed in surface soil at a limited number of locations at FTP-3A, FTP-3B, and the depression north of the access road. Chromium concentrations exceeding the RBC were observed at one subsurface soil location at FTP-3B. Arsenic concentrations were greater than background in sediment samples.

- Concentrations of TRPH, diesel, and gasoline above Alaska cleanup levels were observed in localized hot-spots within FTP-3A and FTP-3B and one location just north of the access road. At this location, lead concentrations were also elevated.
- The pesticides 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were detected in surface soil and sediment at FTP-3A and the depression north of the access road at levels exceeding RBCs.
- Two dioxin congeners were detected at levels exceeding RBCs in surface soil, subsurface soil and sediment at a limited number of locations across the FTP Source Area. In some cases, the presence of these compounds may have resulted from the burning of chlorinated organic compounds at the FTP Source Area.
- Fluoride was detected above background and RBCs in two wells downgradient of FTP-3A (AP-6156) and FTP-3B (AP-6149).
- TRPH was detected in groundwater at a background well and at downgradient wells along the eastern edge of FTP-3B.
- Chlorinated hydrocarbons were detected in background wells and wells downgradient of FTP-3A.
- Benzene concentrations in groundwater at FTP-3B (AP-6150) exceeded the RBC.

Table 9-1

COPCs DETECTED IN ENVIRONMENTAL SAMPLES COLLECTED FROM SOIL AND GROUNDWATER LANDFILL SOURCE AREA OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

COPCs	Soil and Sediment	Ash	Groundwater
Inorganics			
Arsenic	X	_	Х
Barium	X	Х	X
Cadmium	X	_	
Chromium	X	<u> </u>	
Fluoride		<u></u>	X
Lead	X		
Manganese	X	х	X
Vanadium	X	X	
Organics			
OCDD		X	
HpCDD		X	
4,4'-DDE	x		
4,4'-DDT	X	_	
Benzene		_	X
bis(2-ethylhexyl)phthalate	X		х
Dieldrin	X		
Chlorinated Hydrocarbons	X		х
Petroleum Hydrocarbons	Х		Х

Key:

- = Not applicable.

COPCs = Chemicals of potential concern.

OCDD = Octachlorodibenzo-p-dioxin.

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Table 9-2

COPCs DETECTED IN ENVIRONMENTAL SAMPLES COLLECTED FROM SOIL AND GROUNDWATER COAL STORAGE YARD OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

COPCs	Soil and Sediment	Groundwater and Surface Water
Inorganics		
Antimony	_	X
Arsenic	X	_
Barium	X	
Beryllium	X	_
Cadmium	X	
Chromium	X	_
Copper	X	_
Iron	_	X
		-
Manganese	X	Х
Mercury	X	
Selenium	X	_
Vanadium	X	-
Organics		
Benzene	X	X
BTEX	X	X
Dioxin and furan congeners	X	Х
4,4'-DDT	X	_
Dieldrin	-	Х
Chlorinated Hydrocarbons	X	Х
Polycyclic Aromatic Hydrocarbons	x	
Petroleum Hydrocarbons	Х	X
PCBs	X	
bis(2-Ethylhexyl)phthalate		X
Heptachlor		Х
Heptachlor Epoxide	_	Х

Key:

- = Not applicable.

BTEX = Benzene, toluene, ethylbenzene, and total xylenes.

COPCs = Chemicals of potential concern.

PCBs = Polychlorinated biphenyls.

Table 9-3

COPCs DETECTED IN ENVIRONMENTAL SAMPLES COLLECTED FROM SOIL AND GROUNDWATER FIRE TRAINING PITS OPERABLE UNIT 4 FORT WAINWRIGHT, ALASKA

COPCs	Soil and Sediment	Groundwater
Inorganics		
Antimony	X	<u> </u>
Arsenic	X	X
Barium	X	X
Cadmium	X	
Chromium	X	_
Fluoride	_	X
Lead	X	- ,
Manganese	X	x
Vanadium	X	
Organics		
Dioxin and furan congeners	X	_
4,4'-DDD	X	-
4,4'-DDE	X	
4,4'-DDT	X	
Chlorinated Hydrocarbons	X	X
Petroleum Hydrocarbons	X	X
Вепzепе	_	X

^a For this table, soil refers to surface soil, subsurface soil, and sediment.

Key:

- = Not analyzed.

COPCs = Chemicals of potential concern.

HpCDD = Heptachlorodibenzo-p-dioxin.

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